The Engineer

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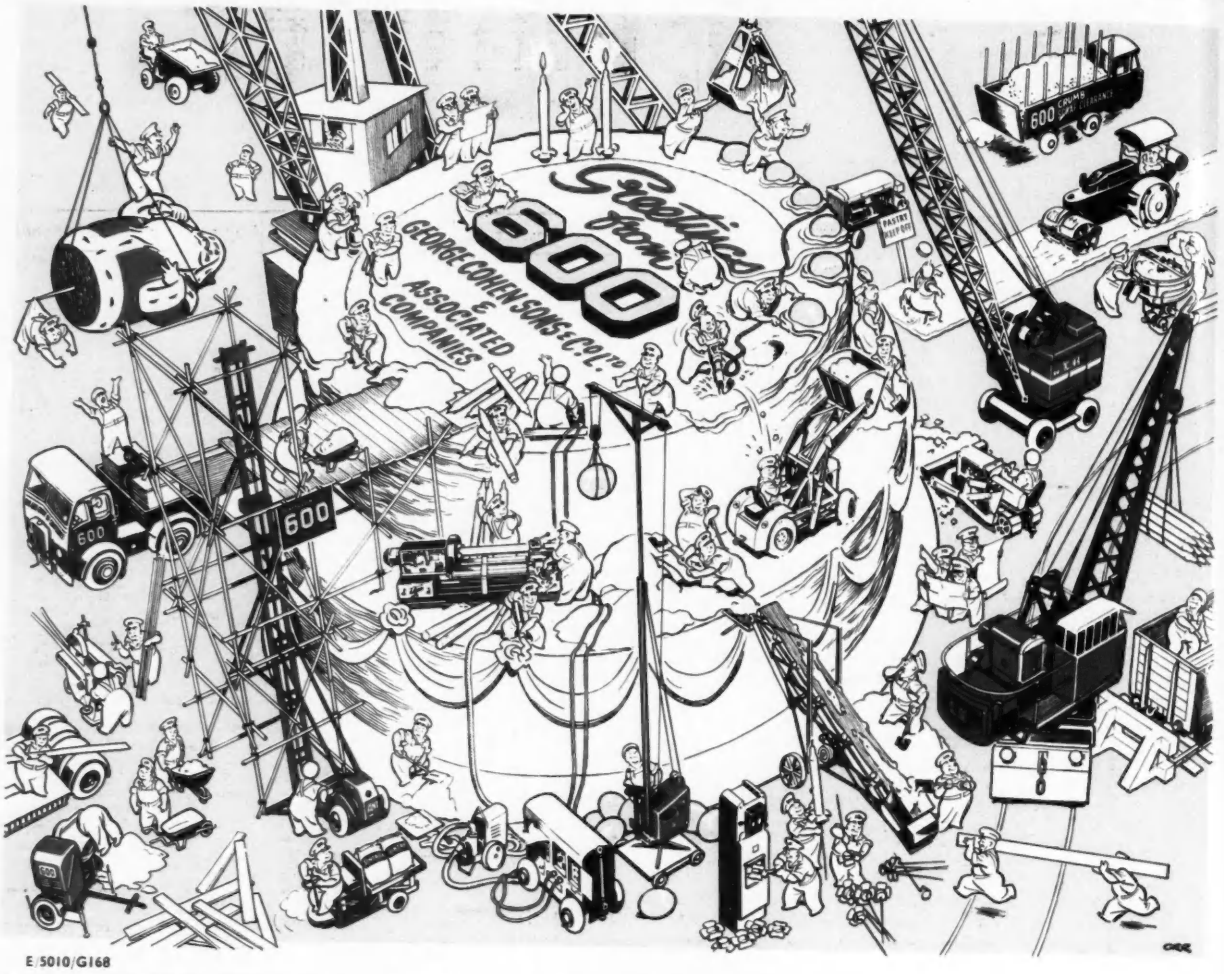

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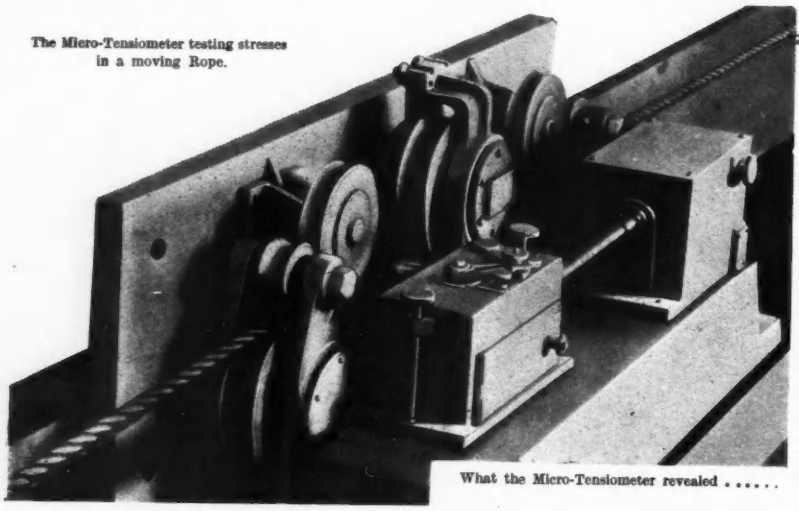
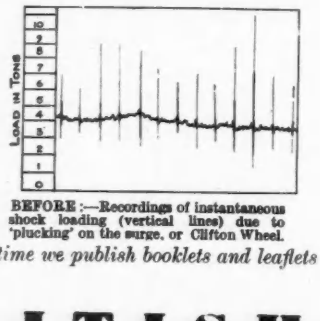
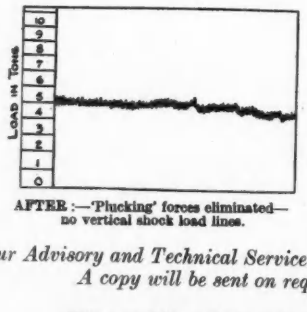
The Micro-Tensiometer testing stresses in a moving Rope.



What the Micro-Tensiometer revealed .....



BEFORE :—Recordings of instantaneous shock loading (vertical lines) due to 'plucking' on the surge, or Clifton Wheel.



AFTER :—'Plucking' forces eliminated—no vertical shock load lines.

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Meet our Micro-Tensiometer. A little chap whose uncanny recording of Rope stresses makes him worth his weight in money—to the Rope user. For instance, at a certain Northumberland colliery, our Advisory and Technical Engineer was asked to investigate the continued breakage of clips on tub haulage. Was it due to shocks imposed by 'plucking' of the Rope on the surge wheel? Our Micro-Tensiometer proved it beyond all doubt; and, by certain mechanical modifications, clip breaking was eliminated and Rope life doubled. This particular problem may not be yours; but why not let our Advisory and Technical people see if they can help you?

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A Seven-Day Journal

F.B.I. Statement on the Economic Background

At the beginning of this week, the Federation of British Industries circulated to its members a statement intended to promote a fuller and better understanding of the present economic situation as affecting industry. The greater the understanding, the Federation claims, the better is the hope of minimising the economic ill effects of the accelerated rearmament forced on the Western Powers by world events and the fresh impetus given to the forces of inflation by the rise in raw material prices which has accompanied it. Referring to the growth of the country's total industrial production and to the rising trend in productivity as "substantial achievements," the statement says that "it would be unwise to allow them to blind our eyes to some very real difficulties that have appeared in recent months." Among them are mentioned the scarcity and increased prices of many materials and the gravity of the fuel and power situation. Until adequate supplies of fuel and power and raw materials can be assured, the statement points out, there can be no security in our industrial outlook. Another section of the statement deals with the physical and financial consequences of the defence programme, commenting upon the danger of assuming that rising productivity will of itself make room for the new programme. It is in many of the industries which have most strikingly improved their productivity that the impact of the increased defence programme will be greatest, and for a time, the Federation warns, the change-over of production must hinder output. Room may therefore have to be found for rearmament at the expense either of some exports or of some production for the home market or a combination of both. Yet, the statement adds, "if we are to continue to pay our way exports to the dollar markets and to the Commonwealth should be maintained, if not expanded." The concluding part of the statement makes some observations on dividend policy. The F.B.I. says that it objects strongly in principle to rigid dividend limitation. In the Federation's view, it should be for each board to decide, in the light of all the relevant circumstances, what is the right dividend policy to follow from year to year. General considerations, the exercise of ordinary prudence, and, in particular, the statement ends, the need to provide enough for replacement costs may well mean very little, if any, increase in the total of the sums distributed as dividends.

Diesel Locomotive Productivity Report

On Wednesday last the Internal Combustion Group of the Locomotive Manufacturers' Association of Great Britain, at a luncheon in London, started action on the recently published report of the Diesel Locomotive Industry Productivity Team. At this luncheon Mr. Gerald Collingwood, the chairman of the group, stated that arrangements were in hand for the holding of a conference at Blackpool, in February next, to consider the report in detail. At this conference representatives from all levels in the industry would split up into discussion groups in order to deal expeditiously with all sections of the report. The various recommendations received from the groups would then be dealt with individually by member firms and afterwards by the group as a whole. In making this announcement Mr. Collingwood added that action based on the report had already been taken by individual firms in their works. The Minister of Supply was present at the luncheon and after congratulating the team on its report, said that it expressed many of the same basic problems as other reports. The difficulty was to adopt the mass production methods of the United States for the betterment of production in this country, where much smaller numbers of locomotives were manufactured to special requirements. Despite this difficulty, the report did show many ways in which management and organisation could be improved. Colonel I. A. Marriott, the leader of the team, told of the great help and hospitality received from industry in the United States. He pointed out the value of the productivity team reports to industry in this country and said that the least we could do to show our appreciation was to give the Americans full information as to what the teams did when they returned and what value they had been able to obtain from all they had seen. The next speaker, Sir Vincent Tewson, said that the team had produced a courageous, balanced and readable report, which would promote much thought in the industry.

A Training School for Technical Teachers

The Ministry of Education has announced new arrangements, which have been made for the training of teachers of technical subjects. Under the Emergency Training Scheme, which is drawing to a close, a beginning was made in providing full-time training for experienced personnel from industry wishing to teach in technical colleges, and similar institutions, including secondary technical schools. Now, as part of the permanent training arrangements for technical teachers, three colleges, which have been in use for this purpose in London, Huddersfield and Bolton, are to continue the work. These colleges will in future be maintained by the local education authorities concerned. Courses, normally of one year's duration, will be open to persons not under twenty-five years of age, who already possess appropriate technological or commercial qualifications in their special subjects and who have had practical experience in industry or commerce. The qualifications include a degree or professional equivalent, Higher National Certificate or the full Technological Certificate of the City and Guilds of London Institute. The College authorities will be responsible for the selection of the students. Tuition will be free and there will also be free board and lodging or a day maintenance allowance for non-residential students, subject to a contribution from the student in accordance with his financial circumstances. Students may also qualify for additional grants, including a personal allowance, vacation allowance, and dependant's allowance where appropriate.

Building Research Report for 1949

The report of the Building Research Board for 1949 has now been issued by the Department of Scientific and Industrial Research. This report states that the work of the Building Research Station has always extended beyond the laboratory; and field work and full-scale tests have long been an essential feature in some programmes. In this direction it is noted how, in recent years, the scope of field investigations has broadened to the increasing benefit both of the industry and the station. Field work of this kind included soil mechanics, stresses in building structures and bridges and the heating, ventilation and sound insulation of buildings. During the year in question studies were made in full-scale trials of the use of electro-osmosis for stabilising silts and for drying out the centre of a clay embankment in Scotland. It was hoped, by measurement of the yield of water from cathode wells placed on the bank and the amount of electrical energy expended, to be able to assess the improvement in the strength of the bank following the treatment. In investigations on building sites into the factors affecting the variability of the quality of site-made concrete, it was found that striking improvements were obtained when better control was introduced. In pointing out that earth pressures on temporary supports to excavations are of much interest to engineers, the report said that, following some earlier measurements, an opportunity occurred for systematic measurement on a large constructional project. By arrangement with the Ministry of Works a start was made on long-term trials on the stresses in steel framed structures and the effect on them of differential settlement.

Suspension of Marshall Aid

The Chancellor of the Exchequer, Mr. Hugh Gaitskell, announced in Parliament on Wednesday of last week that, following discussions between the Governments of the United Kingdom and the U.S.A., it had been agreed to suspend Marshall Aid to the United Kingdom from January 1, 1951. In reaching that decision, the Chancellor said, the two Governments had been guided by two considerations: first, the economic recovery of Britain and the sterling area as a whole had made such good progress that the dollar deficit had in recent months disappeared; and, secondly, the defence programme of the U.S.A., which included the Mutual Defence Aid Programme, would now impose new and heavier demands upon that country's economy. Since the beginning of Marshall Aid, the Chancellor added, the United Kingdom had been allotted a total of 2694·3 million dollars, and goods and services financed under allotments already made would be reaching Britain for some months to come. The Chancellor went on to explain that the United Kingdom would remain a full participant in the Organisation for European Economic Co-operation and the European Payments Union. Certain programmes, he said, particularly those for fostering overseas development, for the production of scarce materials, and for the interchange of technical knowledge to encourage higher productivity, would be maintained. But, the Chancellor continued, the suspension of aid under the European Recovery Programme did not mean that the recovery of the British economy was complete or that the financial resources of the sterling area were adequate. Both Governments recognised that part of the improvement in the position of the sterling area was due to external factors which might well be temporary.

The B.B.C. Television Service

The Director-General of the British Broadcasting Corporation, Sir William Haley, announced on Friday last that the B.B.C. proposed to expend over 60 per cent of its capital investment programme, in the current financial year and the two years following, on the development of the television service. It is estimated that, over the three years, the amount of money to be devoted to television will be in the region of £4,250,000. Sir William said that in the last three years expenditure by the B.B.C. on television had increased from £722,000 in 1947–48 to £1,984,000 in 1949–50. In the current financial year the figure estimated was £2,702,000, which included both capital and revenue expenditure. He thought it probable that the Corporation would be able to keep to its programme of providing eight new television transmitters by 1954, by which time the service would become available to 85 per cent of the population of this country. The proposed dates for the completion of new stations were Holme Moss, for the North of England, mid-1951; Kirk O'Shotts, Central Scotland, end of 1951; and Bristol Channel, mid-1952. There would also be low-power stations at Newcastle and Southampton in 1952, Belfast and Aberdeen in 1953, and Plymouth in 1954. Sir William added that research into colour television had already begun and the Corporation intended to spend up to £750,000 on the purchase of experimental colour equipment. Experiments with colour television would enable the B.B.C. to decide which was the best system, but it was unlikely that any colour service would be available within the foreseeable future.

Productivity in British Industry*

No. XVI.—FACTORS AFFECTING PRODUCTION

By E. W. STEELE, M.I.Mech.E., M.I.E.E.,† and W. SYMES‡

EFFICIENT productivity in the engineering industry is dependent on a logical sequence of planning in all the stages leading up to the production of the finished product. Whether production is "mass" or in limited quantity, the ideal to be aimed at is the same and follows a course somewhat as follows :—

(a) The inception of the idea behind the product and the making of first designs and models, whether they are new products or improvements to existing designs.

(b) The testing of the model for function.

(c) Designing for production.

(d) Pilot production and, in parallel, the consideration of tooling and the setting of standards of quality, including tolerances and finish.

(e) Planning of flow production and handling.

(f) The vetting of the production lay-out by time and motion study investigations.

(g) The regulation of inventory, stocks and work in progress.

There are always present special conditions and fortuitous circumstances, which interfere with the application of this idealised sequence, but in the writers' experience the nearer it is approached and worked to, the greater is the productivity attained.

A large proportion of the British engineering industry is necessarily based on small quantity production, in which the solution to each of the stages naturally follows different lines from that for mass production. Nevertheless, the lessons and experiences gained from the latter have had a profound effect on modern small quantity and even one-off production, examples of which will appear in what follows.

Let us examine in greater detail the sequence given above in its application to small lot production.

Inception of Ideas

In the face of increasing local manufacture in many parts of the world, our home industry is more and more dependent on the provision of a flow of new products and the maintaining of the highest class of workmanship. It is of primary importance that we exploit quickly and expertly advances in scientific knowledge and that we no longer allow the initiative in the development of our discoveries and inventions to pass to other countries, as has happened, unfortunately, too often in the past. The writers' experience with products which only a few years ago were bright ideas in the minds of research workers and are now established lines of production, has convinced them of the value of an active applied research department in a progressive factory and, to a lesser degree, of the value of effort spent on more remote and fundamental research work. If it had not been for the sympathy and encouragement given to research workers in the years between 1928 and 1936 the system known as Radar would not have been ready in time to meet the Nazi onslaughts on this country in 1939 to 1943. This development was taken over in the embryo stages and produced in ordinary workshops by very ordinary people at great speed without any importations of staff or facilities from the radio industry. For use in peace-time, ideas which were formulated only a few years ago have led to small scale production of many new types of equipment, such as the electron microscope, acoustical measurement devices, crack detectors and many kinds of scientific apparatus designed to make our production methods better understood and more reliable.

In order to facilitate the flow of new ideas, it is necessary that the research worker and the development engineer be provided with the necessary means to produce quickly and without elaborate drawings working models of the designs they produce.

Testing the Model for Function

Preliminary models of new products should be fully tested for function in the early stages, with a "discount" allowance for the zeal of the inventor. Several models may have to be made in series and in making them the proximity of the model-making shop to the research or development group is of vital importance. When the model testing is finished, the research worker may lose interest and may desire to get on to the next research job, however different.

The timing of the transfer from research to engineering and development requires rare judgment but can nearly always be settled by the closest co-operation between the research group and the appropriate engineering designers. The transfer should take place with full understanding of the research worker's ideas and should help him to feel that he can still claim an interest in the engineering of the job.

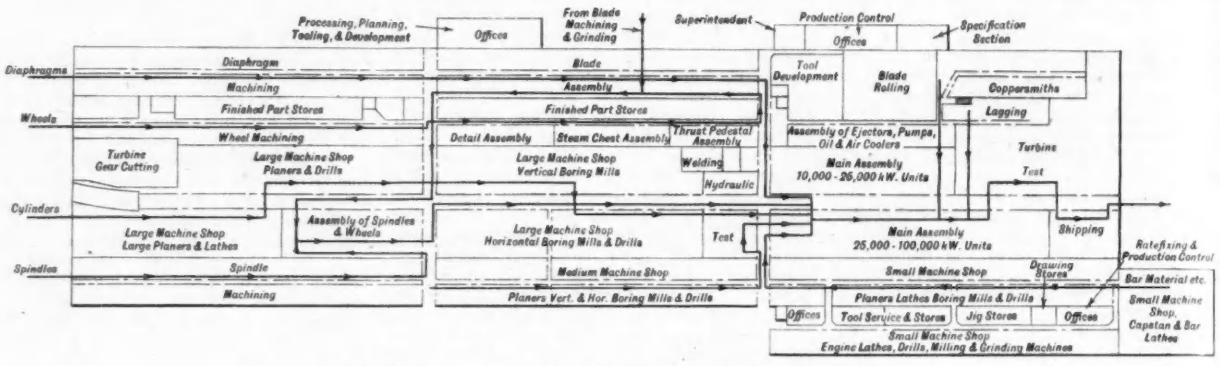


FIG. 1—PRESENT LAY-OUT OF A STEAM TURBINE DEPARTMENT

A rather painful process now commences which many research workers find difficult to understand. If the research group has model workshops with skilled workers who can take instructions "on the backs of envelopes," the more protracted method of making detail drawings of every part generally irritates him. In modern production even of the "one-off" class, the operators very seldom produce completely even one part of the finished product; therefore it is necessary to present to every operator, inspector, foreman and also superintendent and works manager, precise information about each part of the finished apparatus.

Design and Development for Production

In this important stage there should be the fullest possible consultation between the designers and those responsible for production almost from the time the first line goes on the drawing board. The best time-and-motion study takes place on the drawing tables. Production operations can often be eliminated or greatly simplified by the correct selection of materials and production methods. If, as frequently happens, the new designs are improvements on previous ones, the same kind of intimate co-operation between designers and producers is vital; in fact, the writers regard this co-operation as the corner stone of manufacturing efficiency. Much larger economies can be made in this way than by subsequent corrective measures taken when the production programme is launched. It is gratifying to be able to record the increasing recognition which has taken place in recent times by design and manufacturing engineers of the

* No. I, "An Introductory Survey," by B. White, appeared February 17th; No. II, "The Threshold of Productivity," by F. A. Martin, March 3rd; No. III, "High Productivity and Production Costs," by Sir Claude Gibb and Gordon M. Baker, March 17th; No. IV, "Standardisation in the Aircraft Industry," by E. C. Bowyer, March 31st; No. V, "Restrictive Practices," by Arthur Woodburn, April 21st; No. VI, "Research for Productivity," by Dr. D. F. Galloway, May 19th; No. VII, "Consequences of Simplification," by W. D. King and H. Sherburn, June 30th; No. VIII, "Works Extensions," by C. K. F. Hague, July 28th and August 4th; No. IX, "Mechanical Handling," by F. Garner and A. Siddall, August 11th and 18th; No. X, "The Importance of the Craftsman," by F. V. Everard, September 1st; No. XI, "Productivity in the Smaller Engineering Works," by Antony Vickers, September 15th; No. XII, "Productivity in Civil Engineering," by Lieut.-Colonel C. M. Norrie, September 29th; No. XIII, "The Measurement of Productivity," by L. H. C. Tippett, October 13th; No. XIV, "The Contribution of the Machine Tool Industry," by J. B. S. Gabriel, October 20th; No. XV, "Safety in Industry," by Sir Alfred Herbert, October 27th and November 3rd.

† Director & general manager of works, Metropolitan-Vickers Electrical Company Ltd.

‡ Director & works manager, Metropolitan-Vickers Electrical Company Ltd.

value of early joint consultation and co-operation.

In mass production the most serious consequences can arise from design and manufacturing mistakes. All the "good" parts can pile up in the stores or on the shop floor held up for the arrival of the "corrected" parts. All mass production factories have suffered occasionally from periods in which there has been serious loss of output, financial loss and unemployment when, owing to some minor defect such as "cold" soldering in the radio industry, defective engine, clutch and transmission designs in the motor-car industry, untrained personnel in the clock, watch and electrical instrument manufacturing industries, production has been greatly curtailed. One of the greatest needs in the engineering industry now is for young, technically trained men to act as "problem solvers" and "cost reducers," who, acting in full consultation with designers and producers, search for and eliminate difficulties before they develop into serious trouble. In the M-V Company's works, a number of departmental development committees have been set up, each with its model-making section, in order to give the designer and the production engineer what they most require—working models in the shortest possible time.

The late Lord Austin once said that in mass production months were very often spent on the drawing board on the design of a single part. Such concentrated study can seldom be afforded in "one-off" manufacture, but the closer the approach to it, the greater the manufacturing efficiency.

"Pilot" Production, Tooling, Tolerances and Finish

In very large quantity production—e.g., electric lamps—some firms have "pilot" plants on which the first few hundred thousands of a new product are developed and all production snags eliminated, before release into the mass production plant on which the costly capital plant must be kept running without a hitch. For medium and small quantities such an elaborate "pilot" plant cannot be economically justified—but an approach to the ideal can be made. If, for example, an order for 500 articles is received and is likely to be the only order—this quantity can be split into progressively increasing batches of, say, 25, 50, 75, 100, 250. It may mean more paper work but the effort is more than offset by the following advantages.

The first one or two batches can be used as "pilot" quantities for further study of designs for production, for testing tools, for setting standards of quality and finish. The manufacturing costs of the early batches is known long before the completion of the final order and estimating or processing mistakes can be corrected much earlier than if the total quantity is made in one batch. This method of split-batch production was extensively employed on M-V Company's range of war products, and it was very noticeable that nearly all the jobs so handled showed substantial reductions in costs and improvements in finish, as the successive batches were completed.

Flow Production and Handling Methods

One of the major influences of mass production on small quantity production has been the use of "flow" lay-outs and the mechanisation of handling methods. In view of the wealth of handling appliances available, it is very surprising that in "one-off" factories and in some mass production factories, there is such a low degree of mechanisation. An investigation has been commenced in the M-V Company's works of all methods of floor and overhead transport, with a view to reducing the number of "hand labourers"—one of the most expensive types of labour and one in which there is always the largest rate of labour turnover. It is to be regretted that owing to trades union restrictions more of these people cannot be upgraded and trained for better classes of work. However, it is expected that with time and perseverance this difficulty will be overcome. By the end of 1951 the aim is to reduce "miscellaneous shop labour" by at least one-third.

Many years ago a simple incentive scheme was devised to avoid demurrage on railway wagons, with the result that these charges have been reduced to an almost negligible amount. Some time ago time studies of crane service were made, with the result that not only was the expense of new cranes avoided but the service to machine and assembly operators was considerably improved.

It is commonly supposed that line and moving-belt assembly methods were originated by Henry Ford. He adapted them from the Chicago meat-canning factories, who, in turn, had copied them from the Lancashire textile industry, including the manufacturers of textile machinery.

About the year 1810 Charles Babbage, Professor of Mathematics at Cambridge University, wrote a book entitled "Economy for Manufacturers." He described the best methods of studying and organising mass-produced items, such as pins and needles and gave some of the earliest examples known concerning time and motion study. Sub-division of operations described in the book recalls Lemontey's saying that "it is a poor record of a man's life to have produced only the eighteenth part of a pin," which aptly draws attention to the importance of maintaining the interest and enthusiasm of operators engaged on repetitive tasks. Tidy and orderly line of flow production even on "one-off" products does a great deal to allay labour discontent provided it is not pushed to the extent of dehumanising the operators. There is much to be gained from engaging their interests in their work and in the final uses of the products.

Figs 1 and 2 indicate two lay-outs in which flow production on "one-off" products is followed out as closely as practicable. Fig. 1 illustrates the present lay-out of a steam turbine department, and Fig. 2 shows the present lay-out of an electric motor department. Owing to structural limitations, neither of these lay-outs is ideal but both represent a considerable improvement on previous arrangements. Fig. 3 shows a section for turbine blade manufacture, in which the floor transport has been mechanised by power-driven trucks and floor containers of the skid type, to such an extent that it is a rarity to find a single blade or tool on the shop floor. Fig. 7 gives a plan of this blading department and special attention is directed to the inter-operation inspection lay-out, which contains most of the advantages of so-called quality control methods of inspection. Similar principles have been applied in a large jobbing foundry but space does not permit a full description. Foundry developments, except in mass-produced products, have lagged far behind those in machining and assembly. Foundries in general are not attractive places for men to work in. In 1945 the M-V Company required one and a half times as many castings as in pre-war days, with only a little more than half the labour force of moulders and core-makers. Very little help could be obtained from outside foundries so that an increase in output per man-hour was imperative. By means of improvement in working conditions, a relatively high degree of mechanisation (even in a jobbing foundry), and other measures, the company's needs have been adequately met and in addition it has been possible to supply castings to other engineering firms, without any increase in labour force.

In the company the principle of sharing the results of increased productivity has been widely practised. Wherever the workmen co-operate in the introduction of new methods a proportion of the savings is

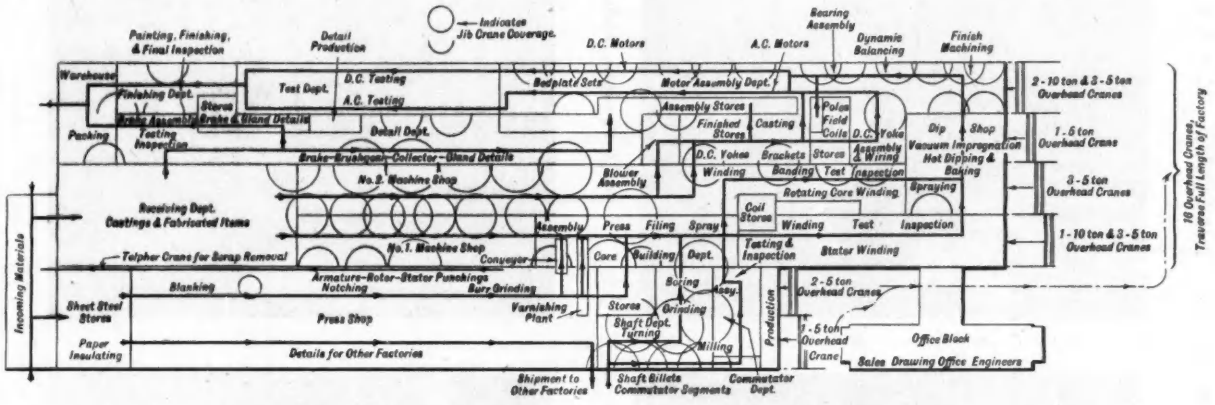


FIG. 2—PRESENT LAY-OUT OF AN ELECTRIC MOTOR DEPARTMENT

PRODUCTION DEPARTMENTS IN AN ELECTRICAL MANUFACTURING WORKS

FIG. 4—FOUNDRY MOULDING SECTION BEFORE REORGANISATION

FIG. 6—ASSEMBLY LINE FOR AN ELECTRICAL DOMESTIC PRODUCT

FIG. 3—BLADING DEPARTMENT

FIG. 5—FOUNDRY MOULDING SECTION AFTER REORGANISATION

paid in the form of additional piecework bonuses. For example, in 1945 a group of plate and machine moulders were earning low piecework bonus for a variety of reasons, partly their own fault and partly that of the management. Discontent prevailed and internal disputes were frequent. The causes were investigated and as a result the flow production and handling in this moulding section was reorganised and new equipment added. The labour costs of castings have been reduced by approximately 50 per cent and in some instances by more. The moulders concerned have increased their piecework bonus by 50 per cent. The group

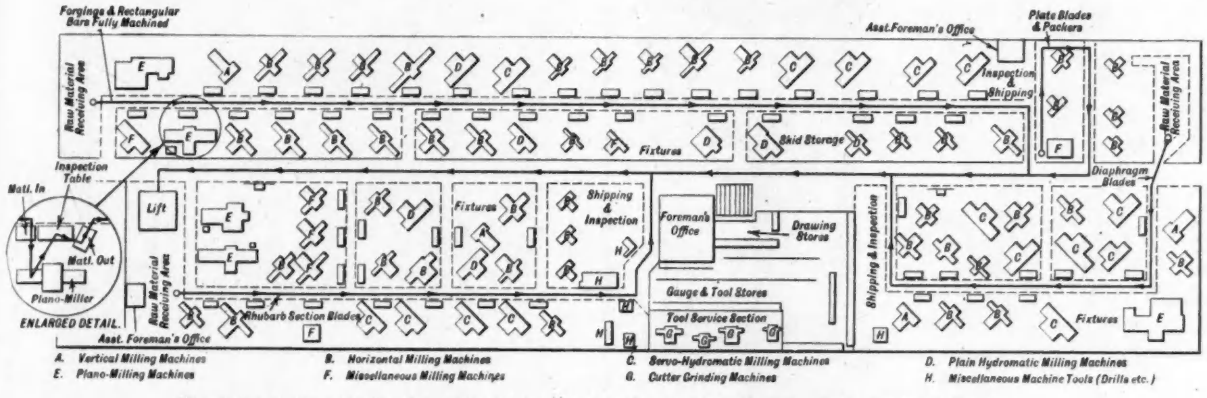


FIG. 7—SECTION FOR TURBINE BLADE MANUFACTURE WITH MECHANISED FLOOR TRANSPORT

much of the stock on to suppliers, as, for instance, in the motor car industry, where the turnover of components is rapid, and, for example, a car body delivered one day is issued as part of a finished car the following day. Much can be done in small quantity production in the same way by careful scheduling of deliveries of components and materials and the reduction of floating banks of parts to a minimum.

Subdivision of Labour and Monotonous Operations

The extreme subdivision of labour operation is subject to certain drawbacks as well as productive of obvious advantages. The main drawbacks are lack of interest in, and reduced application to, the repetitive operations. These can be largely ascribed to the enforced atrophy of the creative instinct. The main advantage is that a much higher material standard of life can be enjoyed by more and more people as productive efficiencies are improved. Although a great deal has been published on the monotony of modern industrial operations, the creation of interest and application has received but scant attention. Some post-war experiments by the M-V.E. Company may therefore be of interest.

Inter-Departmental Visits

The company's Trafford Park works comprises several factories on one site. There are many "feeder" departments, which supply various parts to the main manufacturing departments; they are, in turn, dependent on the quality and timing of services from the "feeder" departments. Although many operatives in "feeder" departments had been with the company more than thirty years they had never seen "their" parts in the final assemblies, nor had they seen the final products in the service of customer and community.

A series of about thirty inter-departmental visits was organised, taking place after working hours, the operatives being paid plain time rates for the time involved. The unanimous opinion of the operatives, including shop stewards and works committees, is that these visits proved to be well worth while. An account is given below of two visits.

The output of the company's large generator department was to a large extent dependent upon a group of approximately fifty girls employed on the taping of generator stator coils. The work was dirty and unattractive, although some improvements had been made. Groups of girls were taken to the generator department, short "lecturettes" were given by technicians, and they were then taken to see generating sets in a power station, in which the coils they made were incorporated. (The groups were told that the electric power for lighting, cooking and heating in their homes was obtained from generators made by the company.) As a result there have been few difficulties in recruitment of women for this work.

A decision was made that a new instrument required small parts produced on automatic lathes, to be more accurate than hitherto, in all dimensions (diameters, lengths, concentricity). The parts were made in a "feeder" department; no explanation had been given, either to setters or operators, for the required greater accuracy. When the new standards were first set, mutual recriminations were frequent. On one group visit the instrument department had assembled some instruments with parts "inside" the new tolerances, and some with parts "outside" tolerances. The lathe setters and operators were then shown both sets of instruments under test and, as expected, those with the "new" tolerances gave greatly superior results. No difficulties have occurred since this comparison was made, either from the operators or inspectors. Aids were provided to the lathe setters and operators, such as optical projectors, which measured the initial lathe settings and subsequent accuracy of product. Similar results were shown by all the other group visits.

General Considerations

Continuity of Management.—The greatest responsibility of managements is to ensure a continuity of good management; higher attainments in the future are required. Industrial welfare depends most upon intelligent, efficient and benevolent leadership. Unless those who occupy responsible positions are justly rewarded, there will be a dearth of men coming forward, willing to make the necessary sacrifices of other pursuits. The choice of men to lead industry should be based on character, ability and merit. Senior executives should, to use a medical term, "have walked the wards," and the company believes in the policy of promotion from within.

The Financial Reward and Security of Employment.—In industry, operatives, managements and shareholders alike are interested in the financial reward for their services. The way to increase the rewards is through greater productivity, which must be achieved before the extra can be disbursed. Reference has already been made to the principle of sharing gains with operatives. All other employees (research, engineering, management and supervision, accounting, &c. staff) are entitled to equal consideration. The company has used widely a method of reviewing staff salaries and giving

is now one of the most satisfactory in the works. Fig. 4 illustrates this moulding section before reorganisation, and Fig. 5 after reorganisation.

Time and Motion Study Investigation

Although the late Dr. F. W. Taylor made time and motion study one of his major contributions to the science and art of management, the engineering industry in this country does not yet seem to appreciate the importance of this subject. The aims and objectives are much misunderstood by both employers and their operatives. For nearly thirty years past the company has used a time and motion study section with great effect.

Before any new shop lay-out is authorised it is "vetted" by the company's time and motion study section and many valuable suggestions have been made in this way.

It is a great mistake to assume that time and motion study can only be applied to simple types of assembly operations. It should be the endeavour in all industrial efforts to reach the highest peak of manufacturing efficiency and this can only be done by measurement of effort on all levels of organisation, for, to epitomise a famous saying of Lord Kelvin, "to measure is to know." Fig. 6 gives a view of an assembly line on an electrical domestic product, which has been subjected, almost continuously, to time and motion study over several years. Very large savings have been made and selling prices correspondingly reduced.

Inventory (Stocks and Work in Progress)

Inflated inventories of work in progress have given many firms great anxiety in recent years. Unbalance in supplies of raw materials, especially iron and steel, shortages of particular kinds of labour, panic buying in times of shortage, have combined to upset the best laid plans for orderly production. The situation is improving with the removal of controls, but the effects of unbalance take a long time to correct. Mass production often lends itself to laying off

THE WORKS AT DONZERE-MONDRAGON

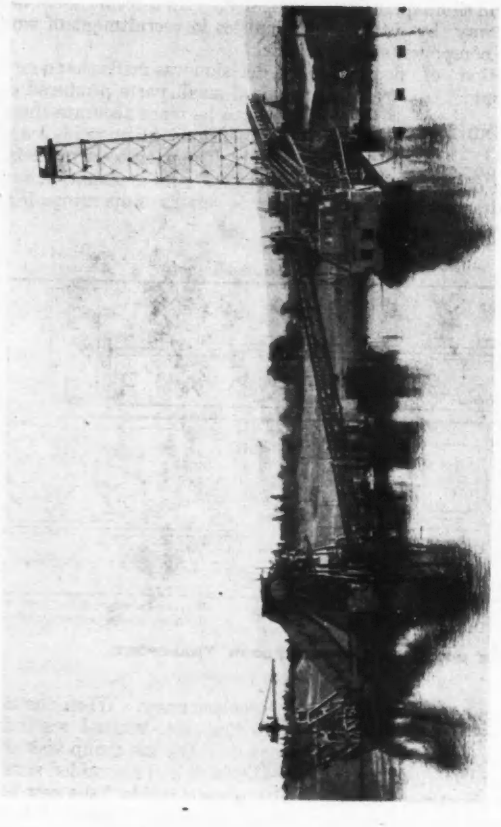


FIG. 18—DREDGE EXCAVATING TAIL RACE CANAL

FIG. 20—EXCAVATION DOWNSTREAM OF POWER STATION

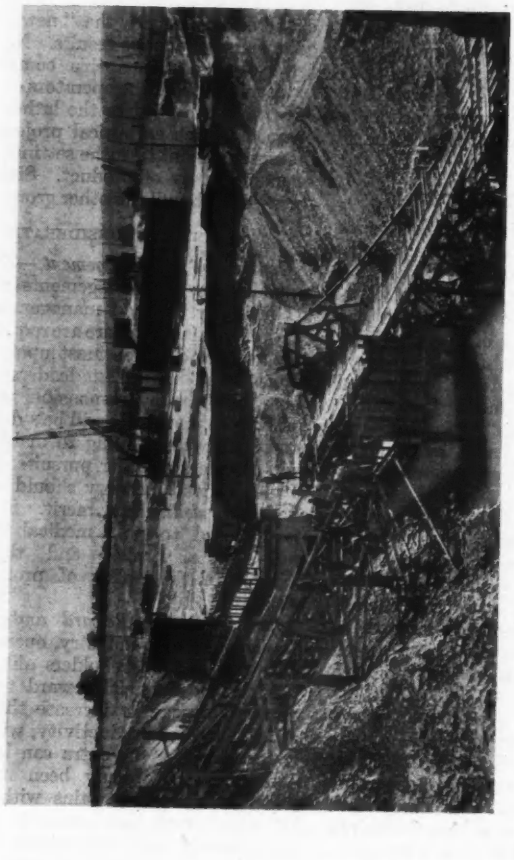


FIG. 17—CONSTRUCTION OF POWER CANAL INTAKE

FIG. 19—HEAD RACE CANAL EXCAVATION

service agreements, without request from the staff members concerned. The customary practice in industry, especially in large firms, is to set limits of salaries for the various positions. We advocate " pay the man, not the job." We believe that these policies have been major factors in the company's increased post-war productivity.

There has been much ill-informed criticism of industrial profits and dividends. Everyone is interested in security of tenure, in addition to the financial reward. By " ploughing back " profits for re-equipment, a firm is ensuring security of tenure for its employees. It is admittedly difficult to get this view accepted by those interested only in immediate gains, e.g., by those who agitate for wage advances.

International Exchange of Information.—We feel that the fullest possible support should be given to, and opportunities provided for, the interchange of all classes of technical information between the manufacturing industries situated all over the world, not merely confining this kind of co-operation to the U.S.A. and our country. Some of the Anglo-American Productivity Team Reports are praiseworthy, but it should be pointed out that the value of such reports will be in the value of the actions which they provoke or stimulate. The engineering industry should be interested, not in reports, but in results.

Whilst there is no doubt that on certain classes of production we have a great deal to learn from America, it is equally true that America has in turn a great deal to learn from the older established industries of this country, particularly from the more progressive and enlightened firms. American wage rates are so high that except for the case of mass production quantities, it has become almost impossible for them to offset high labour rates and overhead charges by extra manufacturing efficiency.

There are many efficient engineering manufacturers in this country from whom the American manufacturers could learn a great deal.

They have more to learn from this country on the subject of employer-employee relationship than in almost any other direction, particularly in the organisation of works committees, staff committees, and joint production committees. We realise that the trades union-employer relationship in U.S.A. is on an entirely different basis from that existing in this country, but in the internal organisation there is little doubt that there is a great deal of room for improvement in consultation with the workers and in the very wide range of amenities and benevolences which are a marked feature of the progressive firms in this country.

There is danger in attempting to transplant methods and practices away from their native soil and conditions. This is largely a matter dependent on the spirit in which co-operation and improvement of design and manufacturing efficiency is undertaken as between management and personnel.

In spite of any past and present difficulties, works and staff committees and joint production committees may be regarded as indispensable to the operation of an efficient manufacturing concern, and further improvements in these directions may be anticipated with reasonable confidence.

The Development of the River Rhone

No. III—THE WORKS AT DONZERE-MONDRAGON

(*Continued from page 534, December 15th*)

THE C.N.R.'s first programme of works consisted of the construction of Genissiat, at the most favourable point on the Rhone for power generation, followed by the compensation barrage of Seyssel. Its second programme utilised the most favourable site on the Lower Rhone between Donzere and Mondragon, where constructional work was started in 1947. At the present time the work on this project is well advanced, and it is expected that the first machines of the Andre Blondel power station will be in service in 1952.

Owing to its vast size this project is interesting both from the points of view of works organisation and the purely technical problems concerned. The estimated cost of the entire scheme is 73 milliard francs (approximately £75 million) and some 6500 workers are employed. Before the works started the C.N.R. bought about one hundred farms, totalling some 2000 hectares, which were situated along the length of the proposed canal. The project has been greatly aided by the supply of American equipment under Marshall Aid, whereas at Seyssel the work has been undertaken almost entirely with purely French resources.

A general idea of the project may be obtained from Fig. 21. There is a dam across the River Rhone near Donzere, just upstream of which on the left bank is a double intake to the navigable power station canal. This canal runs practically level for 17km to the power station, lock and spillway near Bollène, where there is a drop in level of 26m. The tail-race canal then rejoins the river 11km further downstream near Mondragon.

Altogether, the works involve about 50 million cubic metres of excavation and the placing of 800,000 cubic metres of concrete. Ancillary works have included the building of nine main road and rail bridges and the diversion of various left bank tributaries of the river, and temporary homes have been provided for 10,000 persons in several new townships. The hydrological characteristics of the River Rhone at Donzere are given in the table below :—

	Cubic metres per second
Absolute minimum flow	350
Minimum flow occurring ten days per year	560
Semi-permanent flow (six months per year)	1,400
Average flow	1,625
Annual flood	2,600
Ten-yearly flood	5,000 to 7,000
One hundred-yearly flood	10,000

1 cubic metre per second = 35·32 cusecs

Main Dam

The main dam, across the River Rhone, is situated about 1km downstream from the canal headworks. It has been placed at a point of inflection in the curvature of the river, the flow being approximately normal to it. The length of reservoir formed between it and the canal entrance will provide turning space for vessels, should the canal entrance be passed.

The design has been largely based on model tests, and consists of five sluices, each of 31·5m clear width, and one navigable sluice of 45m adjacent to the left bank. Sector gates have been employed to control the river flow, and the normal level of the reservoir will be at 58 N.G.F., about 5m above the normal river level at that point.

A typical cross section through the dam is shown in Fig. 22. The gate is provided with a hinged " shutter," 1·75m high at its top for small regulations of flow. The top level of this shutter is at 58·65, the 0·65m clearance between the reservoir level and the top of the gate being to allow for waves provoked by the mistral on the reservoir.

The sluice gates, together with two of 45m span in the canal, are the largest of their type so far constructed. (Four gates of the same type, each with a span of 18m, have

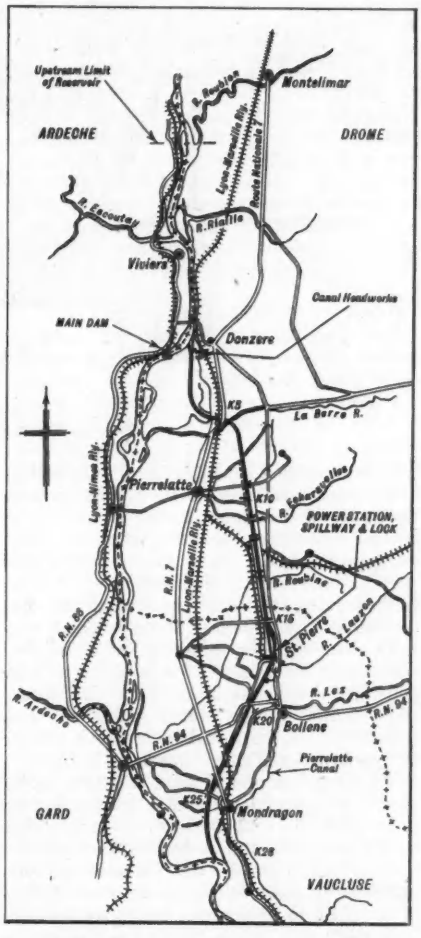


FIG. 21—THE DONZERE–MONDRAGON PROJECT

recently been installed at the barrage of La Vannelle, on the Isere.) They are each 9·15m high and can be lifted by electrically operated winches situated in the piers of the dam, to a height of 15m above the sill. The current is strongest on the left bank of the river, so that for the gate of 45m span provision has been made for the independent manœuvring of the gate and the shutter. For the other sluices, however, the gate can only be lifted when the shutter is in the raised position. The edge of the shutter is provided with several projecting nibs to divide the sheet of water overflowing, and hence to avoid undesirable vibrations.

Construction of the dam was arranged so that navigation of the river would not be interrupted. Thus, at the time of writing, the centre pier has not been built, leaving a navigable waterway in the centre of the stream. On completion of the left bank sluice the centre pier will be constructed and shipping will then pass through the completed sluice until the canal is opened.

The right bank abutment and the two

neighbouring piers of the dam are founded on limestone, but the remainder of the piers rest on clay. The clay is compressible, and tests were carried out to determine the settlement which would occur at those piers founded on it. It was estimated that a sinking o several centimetres would take place fairly rapidly, so that vertical joints were incorporated between the piers and the sill. The framework of the sluice gates would be able to take up a movement of about 0·05m, it was estimated, and for larger movements provision has been made for adjustment. A generous width was allowed for the watertight joints of the sluice gates, so that wedging of a gate would be avoided, should two piers tilt slightly towards each other.

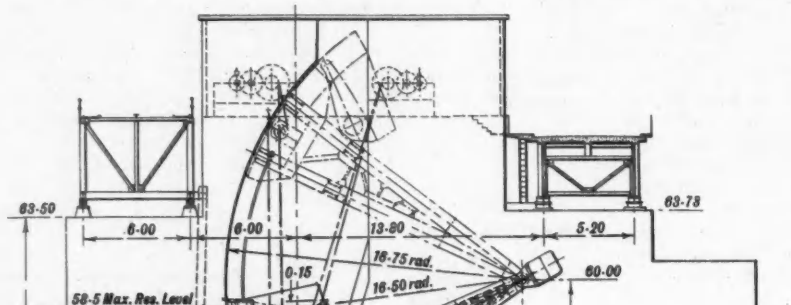


FIG. 22—SECTION OF MAIN DAM

The dam can pass a flood of 10,000 cubic metres per second without a noticeable rise in level at the canal entrance. It is provided with a fish pass, and embarking facilities for tourists, and the works also included the construction of river walls, mainly downstream of the dam, to protect the banks from scour. The reservoir reaches up to the confluence of the River Roubion, 10km upstream of the dam.

During construction the dam is served by four cableways, each of 6 tonnes capacity, and by a footbridge, which leaves free the navigation channel. The right bank abutment and the adjacent pier are being built in the dry behind a cellular steel sheet piled cofferdam, and the river piers were founded on compressed air caissons. On completion of the piers the invert of the sluice is then constructed inside a steel sheet piled cofferdam. Concrete aggregates are obtained from the river bed nearby by cableway draglines, and there is an aggregate plant and a volume-batch concrete station on the right bank of the river adjacent to the dam.

CANAL HEADWORKS

The extensive use of models in the design of hydraulic projects is a characteristic of contemporary French civil engineering practice, which is well exemplified by the works at Donzere. The River Rhone transports a great deal of solid matter in this region, estimated at 12 million cubic metres of suspended solids and 400,000 cubic metres of shingle per year. One of the main problems of the design of the canal headworks was to prevent the ingress of shingle into the canal in times of flood. The solution adopted, after exhaustive tests with scale models, was to provide two separate canal intakes, as shown in Fig. 23, one for navigation and one for the additional water required for the power station.

The line of the navigation canal forms, in effect, a continuation of the line formed by the river upstream in its passage through the Donzere gorge. This canal is relatively wide (100m) and shallow, with a sill level of 54·5 N.G.F. (reservoir level 58·0), compared with a level of about 49·0 of the river bed in the centre of the stream, and takes about one-third of the flow into the canal. The entrance to the power canal is deeper and narrower, with a sill level of 52·5, and is situated on the concavity of the curve of the river bank. This canal takes two-thirds of the flow.

It is well known that on a curve the flow of a river tends to segregate, the liquid flow tending to pass to the outside of the curve and the solids to the inside, on the side of the convexity of the bank. The power intake is therefore favourably situated to avoid the ingress of solids, but as a further precaution it has been built with a sill saw-toothed in plan and projecting in section, as shown in Fig. 24, to encourage solid materials to be directed downstream along the natural curve of the river, where they will be evacuated from time to time by the main dam. This sill behaved very satisfactorily during the model tests, forming an eddy in the stream with a horizontal axis along its length, which caused the solid materials to be carried downstream and towards the centre of the stream away from the sill. If the space immediately under the sill was filled with alluvial material a flood would scour it out again.

The various sills and roundheads, &c., of the two entrances of the canal are, in general, constructed in the dry, but steel sheet piling, in-situ reinforced concrete piles, or compressed air construction are being employed in places, depending on the location and depth of the part concerned. Fig. 17 shows

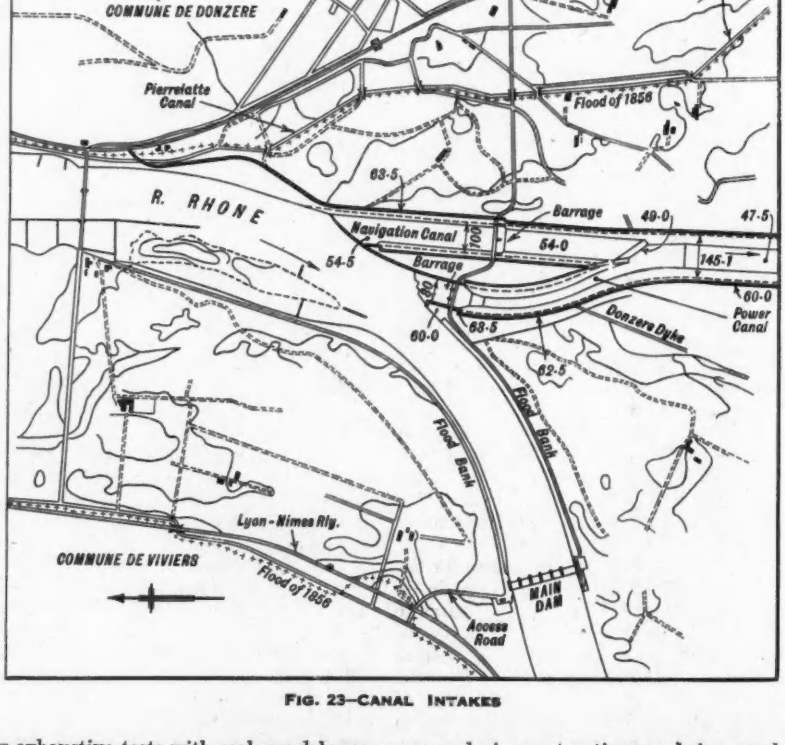


FIG. 23—CANAL INTAKES

the sill of the power canal under construction. This canal is lined with concrete throughout, owing to the high velocities of flow, and the sill is heavily reinforced and founded on the limestone rock underlying the alluvial deposits. The sill of the navigation canal consists simply of a line of steel sheet piles, since the velocities in this canal do not exceed 1·5m per second.

Control of Canal Flow

The headworks also include a barrage across each of the two entrance canals. Control of the flow is necessary at these points, since the level of the reservoir is 2m or 3m below that of the highest floods, and also since from time to time the gates of the main dam will be opened to scour out sands and gravels in the reservoir. During this operation the 15 million cubic metres of water in the head-race canal can thus be impounded. Further important reasons for this control are to mitigate any damage that would be caused to the surrounding countryside in the case of a breach of a canal dyke, and to provide for a very gradual rise in the water level and the surrounding water table when the canal is filled.

The design studies indicated that two separate barrages gave a more economical solution than a single structure downstream of the confluence of the two canals. The navigation canal has a barrage consisting of two sector gates of 45m span and 7m high. When raised, the gates give a clearance of 7m for navigation. Construction is being carried out in the dry with the aid of steel sheet piling, the barrage being founded on alluvial deposits.

The power canal barrage is also being constructed in the dry, but is founded on rock. It consists of three sluices, each controlled by a single vertical lift wheeled sluice gate of 24m span and 6·5m high.

The Canal

More than half of the excavation for the 27km of canal has now been completed, and progress has reached the figure of 2 million cubic metres of excavation per month. When the canal is complete a length of 40km of the River Rhone (over which navigation is very difficult) will have been replaced by the canal (which bypasses 31km of the river) and the reservoir which extends 9km further upstream. The maximum mean velocity of flow in the canal will be 1·3m per second.

The cross section of the canal at normal water level will be 1180 square metres, giving a mean flow of 1530 cubic metres per second. This flow corresponds to a river flow of 1590 cubic metres per second, a flow of 60 cubic metres per second of compensation water being provided. In a normal year this figure is reached for 150 days. The cross section of the canal is practically equal to that of the Suez Canal (1170 square metres) and slightly less than that of the Kembs Canal (1392 square metres). Its slope is 5·5cm per kilometre and the depth and width at normal water level are respectively 10·3m and 145m for the head-race canal and 12·4m and 126m for the tail-race section. The bottom widths are 83m and 59m respectively in the two sections of the canal.

The canal follows a straight course for the first 2·3km of its length along the plain on the left bank of the Rhone. It then turns to the east to avoid the airfield of Pierrelatte, after which it turns again and runs straight to the power station, which is 17km from the intake (see Fig. 21). The route was, of course, chosen to minimise excavation and to limit the height of the berms formed on either side of the canal by the excavation, but one other important factor influenced the choice. Geophysical surveys of the region indicated that an "island" of sandstone rock existed near Bollène, at a higher level than elsewhere, thus providing a convenient foundation for the power station, spillway and lock. The change in level could therefore be situated at that point with advantage, although some extra excavation was involved in the tail-race canal. Similarly, a slight inflection was given to the line of the tail-race canal to avoid a rocky bank near Mondragon. The canal rejoins the River Rhone 11km downstream of the power station. Eventually, when the canal and power station of Chateauneuf du Pape, the next project downstream (see Fig. 5, page 519) are constructed, the new canal will be fed directly from the tail-race canal at Mondragon, without the necessity for further works at the intake.

The head-race canal passes through alluvial deposits of sand, gravel and mud. Extensive tests showed that the sand and gravel were rapidly rendered impermeable, owing to deposition of suspended matter from the river waters, so that no lining was envisaged for the canal, with the exception of a vertical distance of 3m centred at mean water level, which is provided with a bituminous revetment as a protection against wave action. The side slopes of the canal and the berms are 3 : 1, or 5 : 1 in regions where the alluvial mud predominates. In such cases a layer, 2m thick, of sand and gravel is added to face the side slopes. The top level of the berms is 60 N.G.F. except at the headworks, where a level of 63·5 has been adopted as a measure of flood protection.

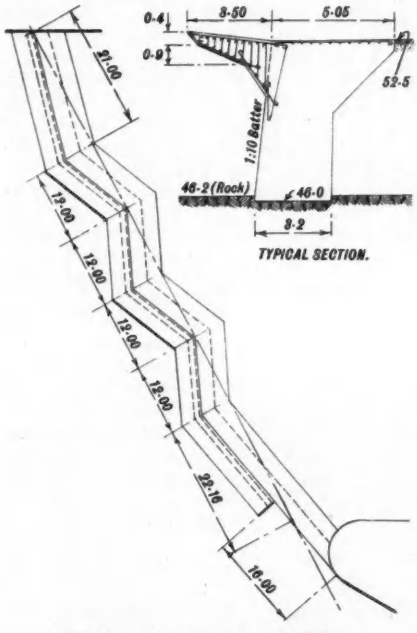


FIG. 24—SILL OF POWER CANAL

Small subsidiary canals are provided on the outer sides of the two berms to limit the height of the new water table introduced by the canal. These small canals will be connected to the permeable material below them at intervals by wells, so that it will be possible to regulate the water table to a level of about 1m below ground level. To maintain a stable transition of the water table on completion of the works the main canal will be filled very slowly over a period of three or four months.

The tail-race canal is generally similar to the description above, with side slopes varying according to the conditions along its length. It is excavated partly in pliocene marl, which is sloped at 3:1 and not revetted at all. Small canals are provided along each side of it, in this case to prevent an undue lowering of the natural water table. These canals will be supplied from the subsidiary canals of the head-race section, and the flow necessary to maintain the water level at the required height will be determined experimentally. The revetments provided in this part of the works will cover a vertical height of 6m owing to the greater variations in water level expected, and will be of precast concrete construction, placed in position with the canal filled.

Canal Excavation

An impressive array of muck shifting plant has been employed on the works during the past two and a half years. Most of the excavation for the head-race canal, the power station and that portion of tail-race canal immediately below it for 800m was carried out in the dry. About a dozen draglines, with bucket sizes up to 6 cubic metres, about fifteen power shovels (up to 3 cubic metres), and some forty scrapers and "tournapulls" (9 cubic metres) have been used for this work, together with a loader of 400 cubic metres per hour capacity, and some eighty dumpers of 7 cubic metres to 10 cubic metres capacity.

This plant is practically all of American origin. In addition, six Belgian bucket-chain excavators, together with railway facilities for transporting the spoil, are in use in the 800m of the tail-race referred to above and shown in the foreground of Fig. 20. The remainder of the tail-race is being excavated mainly by four large bucket dredges, purchased from Holland, each with a capacity of some 500 cubic metres per hour, or some 150 cubic metres to 250,000 cubic metres per month.

The illustration Fig. 18 shows one of these dredgers at work. Excavation is carried out from the pontoon on the left, by means of a chain of 500 buckets. The pontoon on the right supports a belt conveyor transporter, capable of depositing the spoil 80m away. A fifth dredge is in use for part of the head-race canal excavation where the water table is sufficiently elevated with respect to the formation level to allow of this procedure. Each dredge was launched into a pit, excavated beforehand and allowed to fill with water by natural drainage from the surrounding ground. In places part of the excavation has been done by the draglines and scrapers, and two deep ditches, dug to formation level, left along the sides of the canal to facilitate the work of the dredge later on. The photographs reproduced on page 616 give a general impression of the work.

(To be continued)

Development Plan for Tynemouth.—The Minister of Town and Country Planning has approved the development plan of the Tynemouth Borough Council. Tynemouth was the first local authority in the country to submit a plan for the whole of its area to the Minister in accordance with the provisions of the Town and Country Planning Act, 1947. The plan was prepared by the council after consultation with Government Departments and other interested bodies. It is based on the assumption that the population of the borough will increase from 66,000 to about 73,000 in 1972. Its provisions include a number of road proposals, some of which are designed to provide better access to the coast, more land for industry and docks, a new omnibus station, sites for new primary and secondary schools, playing fields and open spaces. An area at the east end of North Shields is to be redeveloped at a high residential density with a number of blocks of flats. It is stated that the plan is intended only to show the broad outlines of development and redevelopment proposed by the council within the next twenty years, but it will be reviewed every five years so as to enable the authority to amend any of its proposals.

The Esquimalt and Nanaimo Railway

By EDWARD H. LIVESAY

No. VII—(*Continued from page 587, December 15th*)

THE following day I left Parksville with train "No. 3," in the cab of diesel-electric No. 8002, pulling three cars, say 175 tons, looking forward to an interesting trip over the tremendous Arrowsmith incline to Port Alberni, the severity of the work involved being clearly brought out by the profile, Fig. 30. "No. 3" awaited the arrival of northbound "No. 1" from Victoria; "No. 2" from Courtenay had passed through southbound three hours before. The enginemen were Messrs. Bugslag and Wiggs, the engine was similar in all respects to No. 8004 of the previous day, and the weather sunny and cool, with spring still just round the corner. "No. 3" left at 3.32, 6 min late, over a generally rising gradient through Coombs to Hilliers. There are long straights on this stretch suitable for speed, but the schedule forbids this. Why save a few minutes over 9 miles only to lose the advantage over the exceptionally difficult and tortuous 29 miles that follow? Time saving is not so important as safety over the Alberni branch; nevertheless, we picked up 2 min to Hilliers.

The track was in noticeably better shape than when I rode to Alberni previously on the steam locomotives; I had not been much impressed by it then. Here, as had been the case along the main line, hundreds of ties were lying ready for the track-gangs. Another fine stretch of the Alberni branch Island Highway (Fig. 31), paralleled the railway through Hilliers for several miles—concrete surfaced with a pebble-roughened asphalt top dressing—and wooden bridges had been replaced by concrete and steel. A mile beyond Hilliers, the foot of the Arrowsmith incline is reached, and the engine began to climb the 1·5 per cent gradient which extends for 12 miles without the slightest break nearly to the peak, stiffening at the top to 2·2 per cent. The air got colder, and snow patches began to appear beside the track. At Cameron Lake, where "No. 3" was nearly back on time, the grandeur of the scenery became more and more compelling. Little "white-horses" ruffled the surface of the lake; Mount Arrowsmith (Fig. 32), 6000ft, appeared briefly through the all-pervading firs, and fresh snow had dusted the forests covering the flanks of the lesser mountains.

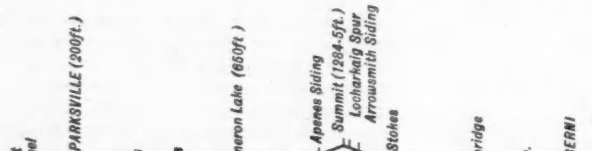


FIG. 30—GRADIENT PROFILE, PARKSVILLE—ALBERNI

Crossing a trestle bridge high up the cliffside as the train twisted its way along a shelf cut in the rock, Bugslag pointed out the spot where he had hit a rock-slide a couple of years before, the engine leaving the track and rolling down a declivity until brought to rest by the trees, with Bugslag practically unhurt. The engine was cut up where it lay; a little scrap was still to be seen among the underbrush. In its fall it had cut the telegraph wires, so one of the trainmen was sent to Cameron Lake station to dispatch a message to Alberni advising the staff there of the accident, and to ask for another engine to be sent up at once. The message ultimately reached Alberni—via Vancouver, Montreal, London, Bombay, Singapore, Australia, Fanning Island and Bamfield, on the west coast of Vancouver Island; round the world to reach a point only 20 miles away.

Nearing the summit two detonators warned us that at Apenes a freight train too long for the siding had left its tail on the line, blocking our passage. It consisted of twenty-six cars, brought up from Alberni in two sections and "married" at the summit for the drop down to Parksville. Out of sight of Cameron Lake here, one looked down into and across a great valley of standing timber, not yet touched by the lumberman, extending far up the mountains on both sides, one of the finest stands left in this part of the island. It was sad to hear that it was soon to be attacked; sentence had been pronounced, but a suspension granted due to the difficulty of access, which modern lumber methods and machinery will, no doubt, nullify. And then, I suppose, one will look down into yet another forbidding wilderness of stumps and slashing, an offence against God, a disgrace to man, and a potential fire-trap, where now stand thousands of majestic firs that it has taken Nature hundreds of years to grow. I am convinced they do not do this sort of thing in Norway, Sweden or Finland, but they do in British Columbia. In those countries compulsory reafforestation has long been the rule.

At the summit, attained 4.31, only 2 min late, it was snowing gently from a bright sunny sky, the air utterly pure and cool, but at once the softer Pacific breeze could be felt coming up the western slope. The train was 1284·5ft above sea level, and the 13 miles from Hilliers, including a rise of 900ft or so and two stops, had been covered in 44 min, 17·5 m.p.h.—very creditable! More road-building was in progress right alongside—the Island Highway, Alberni branch, again (Fig. 32)—with power-shovels, bulldozers and trucks working at high pressure. Apparently both ends of the Alberni branch have been brought up to modern requirements, but the middle still leaves much to be desired. No halt was made at the top, the engine beginning to drift down the western side at once, past little Loon Lake, on which the ice was still unthawed, a foot thick; yet snow disappeared almost at once from alongside as we began the descent, under the influence of warmer ocean air. A high trestle, due for renewal, was shortly crossed, and then a new one, 100ft to the metals; I had not realised that trestle bridges were still being built, yet apparently they are where unlimited timber is available close at hand. The twin cities of the plain, the Albernis, came into view, smoking as usual, and though the Pacific was not visible, the silver glint of the Alberni Canal could be seen nearly to its mouth. Power lines to Alberni cross the track near Stokes, coming from the hydro-electric plant at Campbell River Falls, 50 miles to the north. And simultaneously an unfamiliar smell, anything but attar of roses, stole into the cab. "That's

FIG. 31—THE ISLAND HIGHWAY NEAR PARKSVILLE

the Bloedel, Stewart and Welch Pulp-mill at Alberni" (Fig. 33), said the fireman, with a grin, as he noticed me sniffing. "You can smell it miles away when the wind's in the right direction." It was evidently dead right on this occasion—not the sort of aroma one expects to meet up in the mountains of Vancouver Island, where it is completely out of place, but I suppose both timber and pine-scented air have to be sacrificed in the interests of paper manufacture.

Bainbridge, near the foot of the bank, is another little town with a past. During the first World War it boasted a large saw-mill turning out timbers for the wooden vessels that were built in considerable numbers by the Foundation Company of Victoria, but the demand for wooden ships ceased with the end of hostilities, and subsequently the mill burned down; what goes on at Bainbridge now I do not know—possibly more mutual assistance with dirty linen. Then comes Solly, where the branch to Great Central Lake goes off to the west. This is purely a logging and lumber line. Shortly after, there was a stop at Alberni, and finally at Port Alberni, where Train "No. 3" came to a stand at 5.25 p.m., right on time. The 39 miles from Parksville, 30 of them exceptionally heavy, had been covered in 113 min with half-a-dozen stops, an average of 20·7 m.p.h. Much better than it looks in bald figures, which will be understood when one looks at the profile, Fig. 30.

No. 8002 rode somewhat better than No. 8004, but for what exact reason I cannot say; there was less nosing. The enginemen's explanation was that better care was taken of the machinery at Alberni than at Victoria; as to this I am in no position to express an opinion. Comparing the times of these two runs with those recorded in the earlier articles covering the same trains steam-hauled, there is little or no difference, but the schedules, unchanged with the years, account for this; certainly the diesel engines could do much better if called upon to do so. I understand that 15 min are to be cut from the timing of trains "No. 3" and "No. 4" shortly, but this will still leave the engines with

plenty of reserve to draw upon when things go wrong *en route*.

It will be noted that both trains "No. 1" and "No. 3" were on the light side; this being so, I made arrangements to go up to Arrowsmith with a freight, which I assumed would give me a better opportunity of watching the diesel engines hauling a heavy load up this formidable 17-mile incline. I would be leaving Alberni in the early morning, I

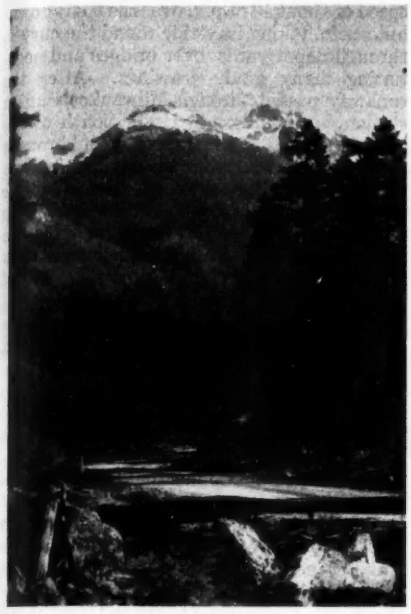


FIG. 32—MOUNT ARROWSMITH AND ISLAND HIGHWAY

was told. Though this would involve getting up at 6 a.m., and hunting up a restaurant ready for business at 6.30, both evolutions involving some difficulty, I promised to show up at the depot at 7.30. But thick fog greeted my emergence into the deserted main street of the still sleeping city. On arrival at the depot the train was found to be in the final stage of assembly. Completed, it consisted of twelve cars and a van (caboose), with engine No. 8006, in charge of enginemen Denny and Mearns—the latter appearing in these articles for the second time, the first being in No. IV—and conductor Bradley. Next the engine was a flat car of rails to be left at the summit, followed by eleven through cars, and at the tail the van.

The make-up ("Consist" in American, a word that sets all my teeth on edge, so I will not use it) and weights of this train may interest readers when compared with cars carrying similar merchandise in Britain; they are taken from the list courteously supplied by conductor Bradley.

	Contents	Weight in tons Contents	Tare
1 car consigned to Victoria	Wood fuel composed of waste from log sawing	40	20
3 cars consigned to U.S.A.	Pulp (each)	45	23
5 cars consigned to U.S.A.	Pulp (each)	45	22
1 car consigned to St. Remi, Quebec	Lumber	40	24
1 car consigned to Wingham, Ontario	Lumber	40	22
Van	—	—	20
		480	265

The total weight, including the car of rails to be left at Arrowsmith and 3 tons of "wheelage"—I do not know what this means—was 810 tons. Quite a heavy load to haul up the severe Arrowsmith gradient. All the vehicles were, of course, 8-wheeled, automatically coupled and air braked. Disregarding the van, the ratio of load to tare is 2 to 1.

Those two cars of lumber—what a tale they tell! Less than a hundred years ago most of Ontario and Quebec was still covered with limitless stands of splendid timber—or so the people of those provinces believed, when Canada was young. Lumber camps and saw-mills were to be found in every part of the country; every farmer was hewing his farm out of the bush, and the long-drawn, musical cry of "Timber!" followed by the crash of the falling tree, was a familiar sound all over eastern Canada. Now—lumber has to be shipped into these same provinces from Alberni, 3000 miles away! It points a moral, and again I infer that Norway, Sweden and Finland have not been thus profligate and short-sighted. Ontario and Quebec have probably learned their lesson, though too late; has British Columbia? I doubt it, or even that it wants to. "Sufficient unto the day is the lumber thereof"—but not unto the morrow. When British Columbia, through reckless and wasteful lumbering methods, comes to the end of its timber resources—and they are far from being limitless as is now fully recognised—there will be no other area of supply on the North American continent upon which the province and the world can draw. Not only the callous lumberman and Nature's lightnings, but the fool with his cigarette-butt and abandoned camp-fire are steadily taking their annual toll of the province's rapidly dwindling forest reserve, though I admit that something is being done at long last to control the menace of fire, by aerial patrol and so on. A North American forest fire can be a terrible thing, and result in incalculable damage, to say nothing of loss of life. For example, in August, 1910, I think it was, at Indian Head, Saskatchewan, the atmosphere became hazy; there was a smell of wood-smoke in the air, and the sun shone red, as through a London fog. It came from a forest fire in Oregon, across the Strait of Juan de Fuca from Victoria, 1500 miles away, hundreds of square miles of timber going up in flames. The smoke, carried by a steady westerly wind, crossed four mountain ranges and the whole width of the continent, 4000 miles, to the Atlantic—and possibly to Britain, for all I know!

The train got under way at 7.50 a.m., and as usual with the diesels the start was very easy and gentle despite the heavy load. This is undoubtedly one of the advantages of electric transmission of power to all four driving axles and ample adhesive weight; a train can be started with the utmost smoothness, and acceleration attained without any snatching or to-and-fro movement, with the risk of broken drawbars. The fog was clearing and the sun trying to break through as the train climbed higher and higher into the mountains, an eerie effect being produced by the tops of trees rising out of a sea of mist. No stops were made on the way up, a steady 12 m.p.h. being maintained, checked by timing between mileposts. Arrowsmith siding was reached at 9.13 a.m., 17 miles with a 1200ft rise covered in 83 min, an average of 12·3 m.p.h. Here the flat car was detached and taken on to Locharkaig spur, where some rails were thrown off and the car left. Leaving the train at Arrowsmith to await the second section arriving later in the day, the caboose was picked up and taken back to Stokes, engine trailing. As this is against safety rules—for obvious reasons, such as the risk of hitting rocks unseen by the engineer—over this much-curved line, the Stokes siding was utilised to get at the right end of the caboose. This achieved, No. 8006 subsided into a "stand-easy," waiting for train "No. 4," which had left Port Alberni at 10, to pass, slow, and pick me up. I filled in the idle minutes by looking round the caboose, finding it considerably more comfortable and "homey" than its British opposite number, last sampled on my Toton-Cricklewood "Garratt" run in 1940 and the blackout. This van was fitted with beds, table, lockers, benches—even an armchair for the conductor if I remember rightly—and a large coal stove for cooking and heating, while the cupola gave a fine lookout in all directions. There was the usual open platform at both ends. Austerity always seems to be considered good enough for the British railroad man—why? Even the lockers of that L.M.S.R. van, used as seats, had no cushions—again why? To make the men tough?

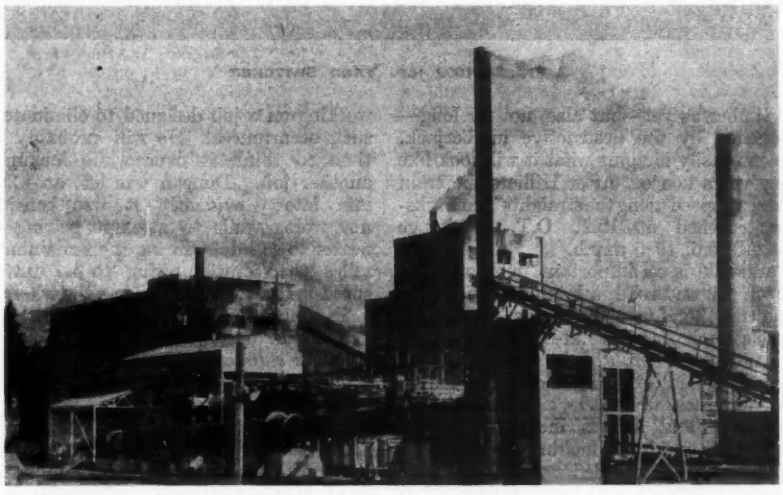


FIG. 33—PULP MILL AT ALBERNI

Engine No. 8002 was again my conveyance on train "No. 4"; it slowed and picked me up at Stokes as arranged, at 11.06; all fog had disappeared, and the wide sweep of the Alberni plain lay spread out under a bright sun, the air pure and cool, untainted by pulp-aroma, the wind having changed in the night. A superb view of Arrowsmith came into the picture right ahead, its dazzling white crest standing out against the blue sky (Fig. 32), as we neared

the summit, but at this supreme moment the film in my camera must needs jam.

Killing time during the disposal of the rails I discovered a trickle of water coming from the rock wall of the cutting, dribbling down over pendant icicles into the ditch, and then apparently running both ways, east and west, into the Strait of Georgia and the Pacific, just as happens, too, at "The Great Divide" in the Rockies. This also was a watershed, on Vancouver Island's backbone; Moses with his staff never struck finer water from the rock than this crystal, throat-numbing nectar. The summit was passed at 11.15, so the 3·5 miles from Stokes, including a rise of 300ft, had been covered at 23 m.p.h.

Drifting down from the peak at 15 m.p.h., Apenes, except for its siding only a name on the profile, was passed non-stop. It might be mentioned that many of the names in these articles do not indicate towns or villages, but merely flag-stations, sometimes without a building of any sort; they have position but no magnitude. One could almost envy the sectionman's place of residence at Cameron Lake, surrounded by Nature's glories. What a place for the "lonely heart" to nurse its sorrow, and find balm. Some of the finest scenery of the whole line is around here; one looks down into a sea of fine timber as yet—but alas, not for long—untouched by the destructive lumberjack. One can easily imagine what it will look like a few years hence. After Hilliers the train picked up speed along the straights into Parksville, reached at 12.20 O.T.; average from Alberni, 19·5 m.p.h.

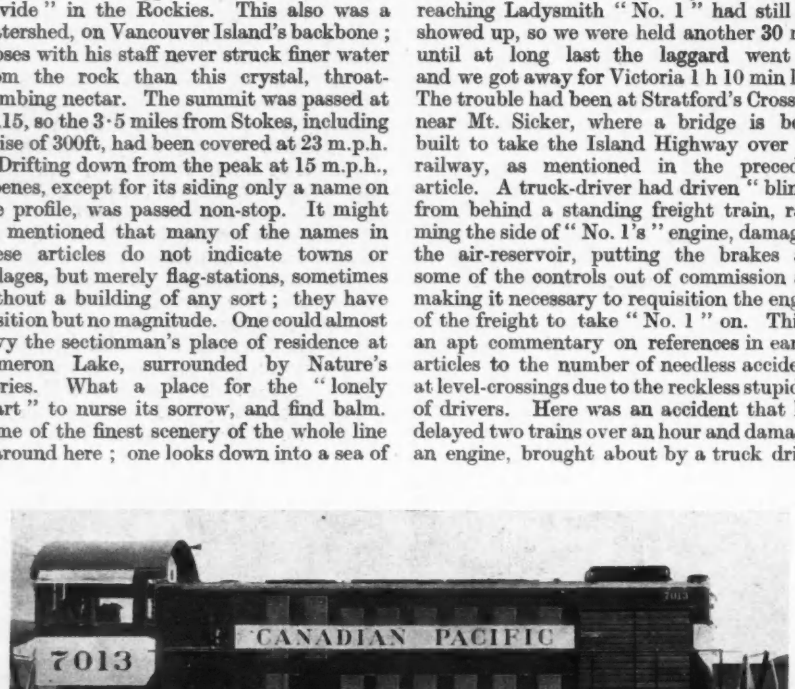


FIG. 34—1000 H.P. YARD SWITCHER

Parksville is an important junction-point of both rail and road, a branch of the latter going off here to Alberni, as mentioned. A fine stretch of the Island Highway extends both north and south of the town, a typical piece of the latter being shown in Fig. 31. It is four-track, well made, capable of taking the heavy and always increasing traffic, cars, trucks and buses making use of it.

Engine No. 8003 headed train "No. 2," five cars and 275 tons, out of Parksville at 12.48 p.m., 8 min late, the speed rising almost at once along the succeeding straights. The enginemen were Messrs. Droob and Collins. There was a certain amount of nosing, most probably due to the track, which was not yet in good shape after the winter; the engines were said to have ridden better when new. Nanaimo was reached at 1.27 O.T., so the 23 miles from Parksville had been covered at 30·5 m.p.h., with a 7 min stop at Wellington, making the running average about the fastest I noticed during the three days. The north and south-bound trains are scheduled to pass at Nanaimo, and "No. 1" should have arrived 5 min after we did, but it failed to do so, and working on a job designed to eliminate just such occurrences! He will probably have time to think it over while looking for another job. Duncan was left at 4.39, 77 min late; evidently it was considered not worth while to attempt getting back nearer to schedule during the remaining few miles to Victoria, owing to a maximum speed-limitation which affects the whole line.

Talking over this affair in the cab, Droob handed me the latest copy of *The Locomotive Engineer's Journal*, drawing my attention to the following: "A 2-unit diesel locomotive was pulling the 'Hiawatha' at a grade-crossing near Duplainville, Wis., when a truck suddenly attempted to race across the tracks in front of the oncoming streamliner. The result was a terrific collision that tore the forward unit completely away from the second unit and train. All controls in the forward unit were damaged to the extent of making them inoperative, and the enginemen were powerless to stop the forward unit as it raced wildly on by itself down grade into Milwaukee.

"Wreckage from the truck broke the brake cylinders on both sides of the forward unit, thus putting the air brakes out of operation. The fouling of brake levers prevented operation of the brakes. In addition, the truck wreckage knocked off a pipe connection to the main reservoir, putting all air-operated devices, including engine controls, horn and bellringers out of commission. Reversing the traction motors or getting any use out of the dynamic brakes was impossible. The battery box covers were knocked off and one of the rear sill steps and uncoupling levers were struck, which apparently raised the pin-lifter and uncoupled the locomotive from the second unit. The enginemen could exercise no control over the unit and only the fast action of the conductor and other personnel in getting messages to the proper points to clear the tracks prevented a further collision.

"The runaway engine held an approximate speed of about 40 m.p.h. over the 264ft down-hill grade, taking its stride round the curves, through depot yards, over bridges and negotiating many grade crossings. After the runaway passed through Milwaukee's union station, an uphill grade 1 mile south of the city checked its unscheduled run and brought it to an exhausted stop (the enginemen were exhausted too!). Although no loss of life occurred, this accident and its harrowing experience for the workers involved again points to the desperately-needed legislation necessary to curb the reckless handling of trucks over the highway—and especially at grade crossings." Truth is stranger than fiction; who would have imagined such a fantastic train of events, and without loss of life? Yet I do not understand why it was impossible to shut off the fuel supply of the diesel engine; surely there is a fitting that permits that?

I gathered from Collins that fuel consumption, on the passenger trains, was roughly one gallon per mile, including the Clarkson boiler. Cowichan, near the foot of the Malahat incline, was left at 4.51; at Strathcona Lodge I went to the front platform of the engine, to enjoy a grandstand view of the climb, just as was done on the old steam locomotive No. 907. Enjoyable, but somewhat chilly, though the wind did not trouble me long as I backed right up against the radiator; it seemed to divide before it reached me, but there was certainly a draught along the sides! The radiator is enclosed by louvres which open automatically as the engine "revs" up, the roar of the fan then becoming impressive; both subside when the engine idles or drifts. There was nothing for me to do at the front end on the diesel as there had been on old No. 907—the engineer had asked me to open the cylinder lubricators whenever he shut the throttle—diesels look after all this sort of thing themselves, and I could give my undivided attention to the scenery. The Malahat summit was attained at 5.27, the 16 miles from Cowichan having been covered in 36 min, with three stops, at 27 m.p.h. The winding descent from Malahat to Palmers was taken with commendable care, the train finally coming to a stand in Victoria's Store Street station at 6.14 p.m., 64 min late, due to the contretemps at Stratford's Crossing suffered by "No. 1." Thus ended three days of interesting experiences, throughout which I had enjoyed courteous consideration and help from everyone, without exception.

Subsequently, during a visit to the shops at Russells, I looked round one of the engines undergoing a minor overhaul, and I gathered additional items of general information. The diesel engine works at 625 r.p.m., the cylinders are 12¾in by 15½in, and fire in the order 1-2-4-6-5-3. The turbo-supercharger is placed over the generator, beside the exciter; behind the generator is the 3-cylinder air pump, the air being filtered before entry; the blower is behind it. Fuel oil and lubricant are both filtered before reaching the pumps; the filters, three fuel oil and one lubricant, are in line on the right side of the crankcase, easy of access. About sixteen

gallons of lubricant are used per month, the loss in running being inconsiderable, but it is changed if it should become diluted with fuel oil. There are two sets of shutters to the radiator, one thermostatically and the other automatically controlled according to engine revolutions.

The one switcher employed at Victoria is very similar to the twelve road engines (Fig. 23, page 554), but is without the steam heating equipment, and its horsepower is the same, 1000 h.p.

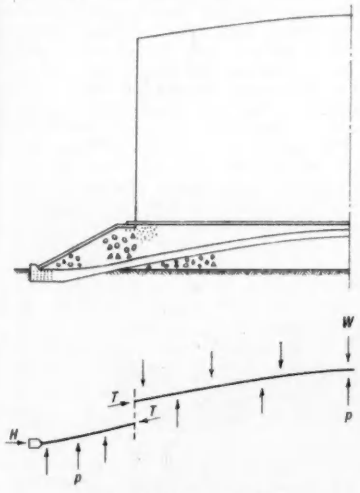
Enquiring as to how the change-over from steam to diesel traction—which has been completed on the E. and N.R.—affected the staff at the running shed, I was told that, generally speaking, the only people who became redundant were the boilermakers, who had been transferred to Vancouver, where steam locomotives are still supreme. The remainder of the personnel has been trained to care for the new power, in which they have acquitted themselves satisfactorily. It is hardly necessary to say that as regards cleanliness in and around the shed the difference is as evident as it is in the cab—no smoke, dirt or disorder is to be seen anywhere.

But I still think a 2—4+4—2 Beyer-Garratt would do the work of the line just as well as the diesels! The boilermakers would then still have work to do at Russells and the fine 20,000 gallon water tanks that now stand forlorn, "their occupation gone," scattered along the length of the railway, would still be useful as well as ornamental. But it was not to be; they and the engines they served are alike a thing of the past, and the future is with internal combustion on the E. and N.R.

In concluding these articles I wish to thank everyone with whom I was brought into contact—Mr. Cowie, the superintendent, Mr. O'Neill, the chief clerk, Mr. Kennedy, ex-superintendent, Mr. Cuthbert, master mechanic, Messrs. Sturdy and Magor, of the public relations department, Vancouver, in particular—which includes all ranks and ratings *en route*, for the help extended to me, and for permission to make the journeys upon which the articles are based. After the many thousands of miles travelled in the cabs of steam locomotives, to which the pages of THE ENGINEER have testified, frankly, I did not look forward to bringing my notebook into the cab of a diesel-electric with any great amount of enthusiasm—I was brought up on steam! But I was agreeably surprised to find how much of interest there was to observe; the runs turned out to have been well worth making, and enjoyable, though much was due to the courtesy of the enginemen and train crews. The aerial photos were taken by the B.C. Aerial Survey Department, and other photographs by the *Victoria Colonist and Times*, the C.P.R., and myself.

A Foundation for Large Circular Tanks

LARGE cylindrical vessels such as oil storage tanks are usually erected on a mat of hard core or other filling material laid direct on the ground without the interposition of a rigid load-distributing footing. As the load imposed by these tanks and their contents is generally of the order of about 1 ton per square foot, this arrangement is perfectly satisfactory where the ground is of average or good bearing value.

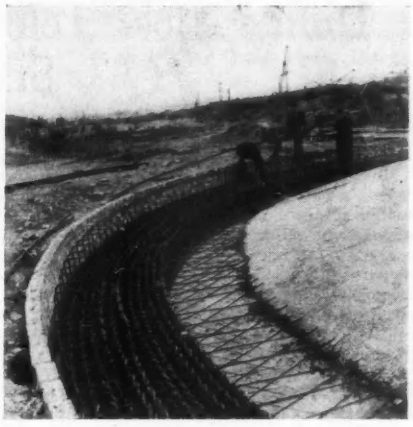


THE DURLEY DOME

It is sometimes necessary, however, to site such tanks in the vicinity of estuaries or other places where the soil is of a clay-silt character of very low shear strength. With the usual arrangement very large settlements, sometimes as much as 2ft or 3ft, are to be expected, and if the shear strength of the soil is exceeded, complete failure of the foundation will take place, resulting in overturning of the tank.

Whilst some settlement, even of considerable magnitude, may be tolerated, and is answered by the provision of flexible pipe joints, overturning cannot be allowed. It is therefore necessary either to pile or to spread the load sufficiently to keep the soil shear stress within safe limits. Owing to the very large total load to be carried the conventional type of spread footing becomes prohibitive in cost and its own bulk adds to the problem of the load to be carried. In order to provide a foundation at an economic cost combined with low dead-weight, a thin shell structure, known as the "Durley Dome," has been evolved by the Reinforced Concrete Steel Company, Ltd., of 12, Caxton Street, Westminster, S.W.1.

The accompanying diagram shows a diametral cross section of the structure, which is circular in plan and concentric with the tank it supports. Within the area covered by the tank the section is the same as an ordinary dome, i.e., it is a circular arc and convex as viewed from above. The portion of the section outside the boundary of the supported tank is also a circular arc, but the curvature is of opposite sign, i.e., concave as viewed from above, and is tangential to the horizontal at its outer end. The perimeter of the structure takes the form of a ring designed to withstand the induced hoop tensions. By virtue of this shape primary bending and shear are eliminated, and the stresses induced by the weight of the tank with its contents and the balancing earth reaction are all direct ones, viz., radial and hoop compression and hoop tensions around the perimeter. When the steel tank is flat bottomed, as is usually the case, it is necessary to provide a hardcore or sand filling between the dome foundation and the tank. To obviate the possibility of this filling sliding down the slope of the dome or otherwise spreading a small curb is provided around the perimeter, as shown in the illustrations.



REINFORCING STEEL IN PERIMETER

The forces acting on the structure are shown in section diagrammatically in the first illustration, in which the central and outer portions are shown divided for the sake of clearness. The weight W of the tank and contents (and hardcore filling where required) is balanced partly by the ground reaction p acting over the same area, and partly by the vertical component of a radial thrust T acting at the boundary of the tank. The thrust T in its turn is balanced by the earth reaction (minus the weight of filling) on the outer portion and the hoop tension H.

The photographs reproduced herewith show some of these domes in course of construction by John Mowlem and Co., at the new refinery at Shell Haven, for the Shell Refining and Marketing Company. These were the first to be built and were specified by the consulting civil engineers, Messrs. Maunsell, Posford and Pavry. The domes are of varying sizes, the overall diameters ranging from 39ft to 73ft, carrying tanks of diameters from 29ft to 52ft. For the largest tank the overall rise of the dome is 6ft. The thickness of the concrete shells, which are reinforced with light square mesh fabric, vary between 6in and 9in. The outer rings are reinforced with bars previously bent to the required radii and placed with their butts uniformly staggered around the circum-

BASES FOR DURLEY DOMES

ference, due allowance being made in the number of bars for the necessary bond development.

The tensile force in the ring is considerable, and high-tensile steel was used for the reinforcement in preference to mild steel.

Some of these domes have now been test loaded by filling the tanks they support with water (about 20 per cent excess over maximum working load). The settlements were much smaller than those of the ordinary type of foundation. In one case a dome was constructed on the site where an overturning failure had previously taken place, and when loaded the differential settlement was insignificant.

Holme Moss Television Transmitting Station

THE television transmitting station now being built at Holme Moss will be the second high-power station to be completed under the B.B.C.'s post-war plan for bringing television within reach of more than 85 per cent of the population. Construction began this year and it is expected that the station will be ready to start broadcasting television programmes about the middle of 1951.

The Holme Moss site is about 9 miles to the south-west of Huddersfield, fronting the Woodhead road. It is the most remote and lonely place yet chosen for a B.B.C. station, but its elevation—over 1700ft above sea level—makes it ideal for television transmissions because, with the very short wavelengths that are used, the range depends in the main upon the height of the transmitting aerial. Many other sites were investigated by the B.B.C.'s research engineers before the one at Holme Moss was finally chosen. The possibilities of each of the more likely sites were tested by setting up a mobile transmitter with an aerial suspended from a balloon 600ft above the ground and recording the strength of the signal received from it, using a van in which a continuous recording could be taken as the surrounding countryside was toured. From these records field-strength contour maps were prepared, showing the probable service area of a high-power transmitter at each site, so that their merits could be compared.

The site covers an area of 150 acres, and on it are being constructed a building for the transmitters, an annexe for a substation and garage, and a 750ft mast to carry the transmitting aerial. In plan the main building is similar to its counterpart at the Sutton Coldfield station, being shaped like an "L." One wing is for the transmitters and their associated equipment and the other will be given over to offices, a viewing room and staff amenities. The construction of the building is somewhat different from that at Sutton Coldfield because of the exposed position of the Holme Moss site and the severe weather which prevails from time to time in these parts. The outer walls are faced with local stone and, for protection against the weather, all windows are double-glazed. The possibility that the engineers may get marooned on the station when the roads are snowed up has also been catered for by providing an extra room for living and sleeping. The building contractors are John Laing and Son, Ltd.

In the main building there will be two transmitters, one for vision and one for sound, both designed and manufactured by Marconi's Wireless Telegraph Company, Ltd. The vision transmitter is to have a power output of approximately 35kW and will employ grid modulation on the output stage. Its valves will be air-cooled except for the output stage, which will be water-cooled. The sound transmitter will be similar to the one at the Sutton Coldfield station, with a power output of 12kW. In addition, space has been provided for medium-power standby sound and vision transmitters to be installed. This precaution has been taken in case the weather during the next few months is so bad that the main transmitters and their aerial cannot be got ready in time for the preliminary test transmissions to be started on them by mid-1951. The vision transmitter will operate on a carrier frequency of 51·75 Mc/s (5·8m) and the sound transmitter on 48·25 Mc/s (6·2m).

The station will get its electricity supply from the British Electricity Authority by two cables, fed from different sources, to minimise the risk of interruption of supply.

About 25 yards from the main building is the mast for the transmitting aerial. When completed it will be 750ft high and have an all-up weight of over 100 tons. For the first 610ft the cross-section is triangular, each face being 9ft wide. Then there will be a cylindrical section, 100ft high and 6½ft in diameter, of which about 18ft has been erected to date. Finally, there will be a tapering square-section topmast, 40ft high, to which will be fixed the transmitting aerial. In the surface of the cylindrical section there are to be thirty-two slots designed for v.h.f. broadcasting in case a v.h.f. transmitter for sound broadcasting is installed at Holme Moss in the future. The mast is held vertical by four sets of stays of prestressed steel wire rope. In the main the mast is similar to the one at the Sutton Coldfield station, except that it has no lift and has been designed to withstand the more severe conditions which may be expected owing to its exposed position and elevated site. Following the usual practice, the base is located by a small steel ball mounted in a socket, forming a pivot, which allows the mast some angular movement in high winds. The mast was designed and is being erected to the B.B.C. specification of structural requirements by British Insulated Callender's Construction Company, Ltd.

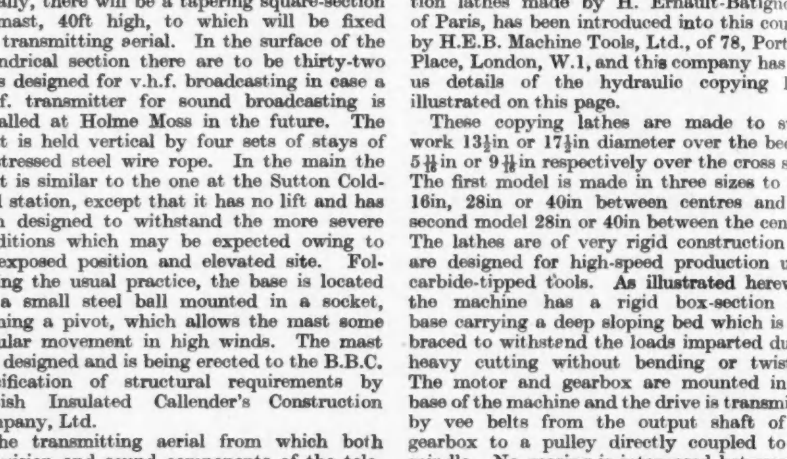
The transmitting aerial from which both the vision and sound components of the television programme will be radiated will consist of eight vertical dipoles arranged in two tiers. Each dipole will have a built-in electric heater to prevent the surfaces from being covered by ice or snow, which would spoil the performance of the aerial. There will also be a smaller mast, 150ft high, with a simpler aerial to serve as a standby in case any trouble develops on the main mast or aerial.

The Holme Moss station will broadcast the same programme as the Alexandra Palace and Sutton Coldfield stations. The vision signals will come from London via Sutton Coldfield, and thence by the special coaxial cable which the G.P.O. is installing. The area within which reception of the television programme from Holme Moss can be relied upon is expected to be roughly rectangular in shape, stretching from Lancaster to Bridlington in the north, and from Birkenhead to Grimsby in the south. This area has a population of over 11 millions, and includes almost the whole of the West and East Ridings as well as most of Lancashire. Reception at any particular place near the boundary of the expected service area will, of course, depend on local factors, such as the height of the receiving aerial and the strength of electrical interference in the vicinity.

A Hydraulic Copying Lathe

A RANGE of copying, tool-room and production lathes made by H. Ernault-Batignolles, of Paris, has been introduced into this country by H.E.B. Machine Tools, Ltd., of 78, Portland Place, London, W.1, and this company has sent us details of the hydraulic copying lathe illustrated on this page.

These copying lathes are made to swing work 13½in or 17½in diameter over the bed, or 5 11/16in or 9 11/16in respectively over the cross slide. The first model is made in three sizes to take 16in, 28in or 40in between centres and the second model 28in or 40in between the centres. The lathes are of very rigid construction and are designed for high-speed production using carbide-tipped tools. As illustrated herewith, the machine has a rigid box-section cast base carrying a deep sloping bed which is well braced to withstand the loads imparted during heavy cutting without bending or twisting. The motor and gearbox are mounted in the base of the machine and the drive is transmitted by vee belts from the output shaft of the gearbox to a pulley directly coupled to the spindle. No gearing is interposed between the vee-belts and the work, and the belts serve to absorb any vibrations which may be set up in the gearbox at high speeds. Spindle speeds below 500 r.p.m. are obtained by engaging a



HYDRAULIC COPYING LATHE

form of back gearing between the vee-belt pulley and the spindle. Machines can be fitted with motors of 8, 12, 15 or 20 h.p., according to the nature of work.

The motor is flange mounted to the gearbox, the whole assembly being mounted on rubber bushes which, together with the vee-belts are the only connection between the power unit and the remainder of the machine. This arrangement is designed to ensure that no vibration is transmitted to the tool or work.

The motor drives the gearbox through a multi-disc clutch which is engaged by a lever set close to the operator's left hand. Movement of this lever in the opposite direction to driving engages a second multi-disc clutch which is used as a brake. This brake can also be engaged by depression of a pedal at the front of the machine.

Spindle speeds are changed by means of pick-off gears, and the machine has twenty speeds between 50 and 3600 r.p.m., each speed normally being 1·25 times that preceding.

The vee-belt pulley in the headstock is concentric with, but quite independent of, the spindle, and the pulley drives the spindle either directly through a dog clutch or, at speeds below 500 r.p.m., through a double gear reduction having a ratio of 9 : 1.

The bearing at the front of the spindle is a special double-taper roller bearing of ample capacity, assembled without any preload, as it was found that at speeds over 3000 r.p.m. considerable heating occurred as a result of preload. At the rear the spindle is carried on a single taper roller bearing which is spring loaded to take up the initial play in the front bearings and to allow for the longitudinal expansion of the spindle.

The spindle is of special alloy steel and the chuck mounting is of the short overhang type, to the American standard A.1–6in. The spindle is bored to 1 7/16in diameter and ground to a No. 5 Morse taper. At the rear of the spindle is a pulley which drives the feed mechanism input shaft through two vee-belts.

The feed shaft is driven through a simple gear system, variations in feed being obtained by pick-off gears similar to those used for the spindle drive. By means of a lever the feed rate can be reduced in the ratio 3·5 to 1, and this change can be effected whilst taking cuts at spindle speeds as high as 2000 r.p.m. Using six pairs of gears, twenty-two different feeds can be obtained with this arrangement, the finest longitudinally being 0·0008in and the coarsest 0·0354in per revolution of the spindle. The transverse feed range is between 0·0004in and 0·0177in. Coarser or finer feeds for special purposes can be obtained by using different vee-belt pulleys. A feed-reversing lever can be used at spindle speeds up to about 2000 r.p.m. whilst running.

Drive from the feed gearbox is transmitted through a cone clutch which is normally held in engagement by a strong spring, but can be disconnected electrically by means of a solenoid and second spring situated at the remote end of the feed shaft. The solenoid is normally energised, but when the copying tracer meets a shoulder on the template, the circuit is broken and releases the second spring and causes the clutch to slip, while the tracer feeds out to clear a shoulder. This mechanism is very sensitive and is stated to maintain distances between shoulders within 0·0015in at feeds up to 16in per minute and within 0·002in up to 27in per minute.

The solenoid circuit is also broken when the carriage meets one of seven adjustable stops situated on a bar below the feed shaft. The cone clutch of the feed drive also acts as a safety device and if the maximum necessary power to the feed shaft is exceeded the clutch slips and avoids damage to the mechanism.

The deep-section saddle is very rigid and carries a hardened tool slide slotted for fixing of front and rear tools. Four transverse stops fitted to a rotating bar on the saddle are used for feeding the tool into preset positions. These stops are mainly used when copying for positioning the rear tools for undercuts and similar work. They can also be used for setting the front tool when taking roughing cuts. The front of the tool slide is also fitted with a micrometric stop for fine adjustment purposes.

As a single-point tool can be used on this machine for turning chamfers, radii and other forms by means of the copying attachment, it is not generally necessary to use more than one front tool, but for special work a four-way toolpost can be fitted. The front tool is clamped in the tool holder in a vertical position instead of the conventional horizontal position. When setting a tool in this front tool holder it is raised in a clamping ring until its edge is flush with the top of the holder block, where it can be rigidly locked in position by the tightening of a single nut. The use of vertical tools eliminates necessity for tool overhang and consequent deflection of the tool when under cutting loads.

The copying device is an integral part of the design and not a separate attachment added to the machine.

It consists of four main elements : a template carrier, a tracer and detection unit, a hydraulic system which transmits the transverse motion of the tracer to the cutting tool, and an electrical system which regulates the longitudinal motion of the cutting tool.

The template carrier at the rear of the machine is carried on two rigid brackets which support both the table for flat templates and the sliding centres for turned patterns.

In the tracer and detection unit at the rear of the tool slide the tracer point is maintained in contact with the template by a helical spring under a pressure of about 3 lb. The tracer arm is free to swing about two axes, one horizontal and the other vertical. Movement about the horizontal axis alters the valve opening in the hydraulic system, causing the tool slide to move across the saddle. Movement of the tracer arm about the vertical axis is detected by a micro-switch controlling the feed shaft motion.

In the hydraulic system a ½ h.p. electric motor drives a small gear pump which supplies oil at a pressure of about 200 lb per square inch to both sides of a piston. On one side of the piston pressure is reduced by allowing oil to escape via the valve in the tracer unit. The two sides of the piston are of unequal area and, the piston is in equilibrium when the pressures on each side are about 200 lb per square inch and 100 lb per square inch respectively. Thus, in the balanced position, there is a considerable valve opening and any slight deviation in this opening brought about by tracer arm deflection immediately produces piston movement.

The cross-feed screw is connected to the piston through two spring-loaded ball thrust bearings, and the nut which transmits the motion from the screw to the tool slide is provided with a backlash compensation nut. A ball-ended lever operating a remote control enables the operator to open or close the valve of the tracer unit and move the tool slide by hydraulic power independently of the template or tracer unit.

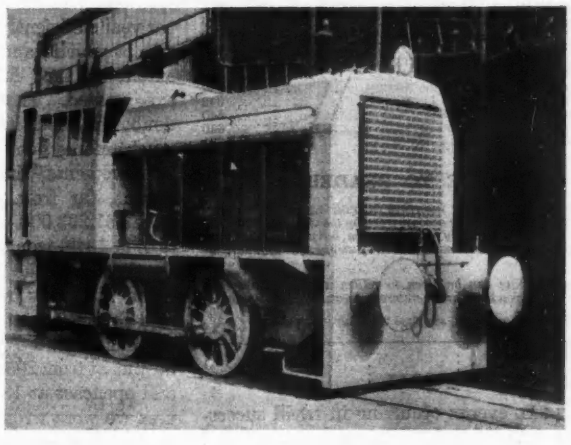
When dealing with the feed shaft drive earlier in this article, it was shown how square shoulders were machined by the disengagement of the drive whilst the cutting tool was moving out of the work. This operation is effected by a micro-switch which detects the movements of the tracer arm about a vertical axis. The micro-switch normally allows current to energise a solenoid at the end of the feed shaft, and, when actuated by the tracer in contact with a shoulder on the template, the switch de-energises this solenoid and energises a second solenoid in the tracer unit. The second solenoid closes the hydraulic valve and causes the tool and tracer to withdraw until the tracer clears the shoulder. The extent to which the valve is closed by the action of the solenoid in the tracer unit is adjusted by a screw to give means of fine control for the speed at which the tool slide moves. This detail makes the cross feed quite independent of the speed of the longitudinal feed and is of advantage when shoulders require a very fine finish. The setting is, of course, quite independent of the speed obtained when surfacing by operating the remote control or when using the mechanical cross feed.

We are informed by the makers that the above lathe is being demonstrated at the showrooms of the Selson Machine Tool Company, Cunard Works, Chase Road, London, N.W.10.

Heavy Steelworks Diesel Locomotive

RUGGEDNESS and simplicity characterise the 40-ton, four-wheel, 300 b.h.p. diesel mechanical locomotive built by the Hunslet Engine Company, Ltd. Leeds, for the Consett Iron Co., Ltd. Site conditions limited the dimensions to a length over buffer beams of 21ft 7in, a height of 11ft 9in and a width of 8ft 4in. Within these limits a locomotive has been constructed having a starting tractive effort of 23,000 lb and capable of hauling an 850-ton train at 6 m.p.h. over steelworks tracks. The power available gives rapid acceleration and 1200-ton loads can be started and hauled in first gear.

A welded box-section supports the engine and ties the 1¼in thick plate frames and is supplemented, at the ends, by a 5in front buffer beam and a 2in rear beam. Large diameter buffer heads obviate locking at sharp curves. The cast steel wheels of 48¾in diameter on the tread have 5½in by 3in tyres, a base of 6ft 6in and axle journals 8in diameter by 9½in long. They are housed in cast steel boxes having phosphor bronze bearings with white metal pockets and phosphor bronze linings against the wheel hubs and horn faces.



300 B.H.P. DIESEL SHUNTING LOCOMOTIVE

The five-cylinder, two-stroke Crossley engine, which develops 300 b.h.p. at 900 r.p.m., is started electrically and is fitted with a reciprocating scavenge pump and a belt-driven centrifugal water pump. A frontal radiator cools both water and oil and a 500Ah battery provides current for the starting motor and lighting. The three-plate self-ventilated friction clutch transmits the torque through a flexible coupling to a four-speed gearbox and thence through reversing bevels, jackshaft, flycranks and rods, to the wheels. One handwheel operates the throttle, clutch and the pre-selective change speed mechanism, which is actuated by air from the brake system. At maximum engine revolutions the track speeds are 4½, 6½, 10½ and 16 m.p.h., the corresponding tractive efforts being 22,400 lb, 14,700 lb, 9300 lb and 5950 lb.

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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COAL

SEVERAL events occurring in rapid succession served last week to concentrate attention on the coal industry. Just after the Coal Board had published a "Plan for Coal" that played down the difficulties of the industry and included estimates of future demand that seemed low in relation to the rapid increase in the industrial output of the country, the Minister of Fuel and Power was forced by events to announce in the House a shortfall in coal production during this year. He also announced his authorisation to the Coal Board to stop exports and import about a million tons of coal from America. Shortly afterwards, in the week ended December 9th Sir Eric Young announced his resignation from the Board, thus leaving the Board bereft of the two members, Sir Charles Reid and himself originally representative of the production side. That event, incidentally, emphasised, also, the point that when an industry is nationalised it becomes the sole employer so that an employee resigning a position within it or being discharged by it has small hope of obtaining other employment within the industry without leaving the country. There was, then, no lack of reason why the public should feel the situation to be disturbing. It is true that indications had not been lacking before these events, to foreshadow a coming crisis. For lately weekly figures of output from the mines had been drooping relative to the corresponding figures for 1949; it was becoming more and more clear that the output of coal could not reach the target of 205 to 210 million tons of deep-mined coal set for the year; and the figure for stocks of coal available at the beginning of the winter was nearly two million tons lower than last year. But until his sudden announcement on November 20th the Minister had seemed to be at pains to argue that the situation was still satisfactory.

The debate on coal supplies in the House on Monday of last week gave vent to the public concern aroused. There was, revealed in the debate as was to be expected, a considerable conflict of view as to what ought to be done to prevent recurrent fuel emergencies each autumn. Wages, conditions of work, absenteeism, the employment of Italian and other foreign labour, and many other subjects that have been under discussion for years past were again commented upon in a debate in which the opposition showed much less desire than usual to "get at" the Government about a nationalised industry. Yet no one, not even the Minister himself, could really get round the fact that the industry is rather conspicuously failing to improve output per head per year sufficiently fast to compensate for the rate at which its manpower is declining. The extent of that failure is, of course, often exaggerated. There can, for instance, be no doubt that had the Coal Board not expended much money on mechanisation and other improvements since the war, deep-mined output, far from showing a small increase from 181,293,000 tons in 1946 to 202,678,000 tons in 1949, would have shown a steady fall. Furthermore, the Minister was also able to make the very reasonable point that the shortfall in output this year was in fact very small indeed. "We estimated deep-mined output at from 205 million to 210 million tons and opencast at 13 million tons. On both figures we were wrong. On deep-mined we shall be less than one million tons below the 205 million tons, an error of under half of one per cent. On opencast . . . we shall be three-quarters of a million tons below our figure." In different circumstances such small deviations from estimates would be negligible. What makes the error serious is the fact that never since the war has the coal-mining industry been able to produce coal at a rate sufficient to meet demands and simultaneously to provide for the growth of adequate stocks. Indeed, in every one of those years supplies for industry and for the generation of power have only been ensured by holding down domestic and export demands and keeping the figure of autumn stocks hazardously low. Had the stock position been better at the end of last winter or had the Government and the Board decided that more adequate stocks ought to be built up before increased quantities could be sold for export, so slight a shortfall below the estimate of less than one per cent would have had little significance. It is in fact an unhealthy sign that so small a deficiency can threaten to produce serious consequences.

It is an ill-wind that blows nobody any good. Deplorable it certainly is that a country containing beneath its earth stocks of coal sufficient to last another 200 years should be carrying "coals to Newcastle" from America for lack of ability to work its own seams. But the stringency in coal supplies that has ruled since the war and bids fair to rule for at least several years to come has forced this nation, heretofore wasteful of coal, to economise domestically and industrially. Certain blessings have followed. For firms thus forced to economise have learned that quite cheap and simple improvements to plant have raised efficiency so much that real profits have resulted; and many an engineer-in-charge has been able, as a direct consequence of the stringency, to obtain the money from his "board" to carry out improvements that he has been convinced for years wanted doing. Nor has industry alone profited. No doubt the Minister was right in the debate to estimate that some two million tons of smoke and soot are dispersed to atmosphere each week in this country. But improved combustion efficiency must still in these last few years have contributed significantly towards keeping the figure down. Yet the scope for further economy is still large. The Ministry has recently had four mobile testing units touring this country—one was described in this journal on March 10th, this year. It hopes soon to have a dozen. Those units have found on average that a saving as high as 22 per cent in fuel usage is possible even at the bigger industrial plants they visit. For our part we suspect that very much bigger savings could be made in numbers of small plants. Quite obviously this field of economy in fuel usage is one in which engineers can profitably operate.

DIESEL LOCOMOTIVE PRODUCTION

REPEATEDLY in these columns we have remarked upon the different characters of the markets served by British and American industries. That difference is particularly well exemplified in the manufacture of diesel locomotives. The British makers have no large home market to supply. They have to depend upon the demands of widespread oversea markets in which rail gauges, loading gauges, axle loadings and operating conditions, not to mention individual preferences for particular designs, vary very widely. By contrast the production problems of American firms seem simple. During the trade depression of the "'thirties" American banks and American railways co-operated with the manufacturing industry of the country to finance an expansion of manufacturing capacity. In consequence, there was created for American manufacturers by arrangement with their principal customers a relatively stable market, and for that market there was developed by the manufacturers a range of diesel power units that have since proved economical in use, easy to control and of high availability. The market so created was not only relatively stable. It was also, by British standards, very large, and it was, furthermore, relatively homogeneous. For though there are many American "railroad" companies and their lines

cover half a continent, there is a single standard gauge of track, a generous loading gauge everywhere, and heavy permissible axle loadings. The existence of such a market naturally encouraged diesel locomotive manufacturers, as similar markets for other goods have similarly encouraged other industries across the Atlantic to the development of that standardisation and simplification of product and to that use of the principles of unit construction that particularly impresses visitors to American factories of many kinds. Those developments were, moreover, as has been often pointed out before, further encouraged by the limited number of craftsmen to be found in the American labouring force. It was this industry, highly organised to meet the demands of a special market, that was visited early last year by a "Productivity" team from the corresponding, but very dissimilar, British industry. The report of that team was summarised in last week's issue.

It is obvious enough by mere comparison of the characteristics of their respective markets that it would be harmful to the interests of British industry if the attempt were made, too enthusiastically, to transplant American methods of diesel locomotive manufacture to this country. But it does not follow as a consequence of the wide difference in the conditions of working of the British and American industries that the visit of a "Productivity Team" must have been valueless. The report that lies before us proves the very opposite. For we agree with the Team's opinion "that many basic engineering principles common in the American locomotive industry can be applied even if in modified form to the British industry." Moreover, even when a team has been somewhat over-impressed (as we think the diesel locomotive team may have been) by American methods, the criticisms implicit in recommendations for closer accord with such methods here by no means lack value. For at the least they must stimulate those who support existing ways to come to their defence, and in defending them to gain a fuller understanding than before of the reasons that led to their development and of the real possibilities of their modification under British circumstances. Thus we welcome the controversial recommendation of the team "that consideration be given to the abolition of piecework and the substitution of an enhanced hourly rate with time study in order to establish agreed standard times." For we have often wondered of late whether in several British industries too much emphasis was not being laid upon incentive schemes and too little attention was not being given to other means of ensuring a high output. We enjoy, too, the provocative suggestion "that if the simplification of methods recommended in this report is achieved craft trades and trade apprenticeship, as at present known in Britain, be abolished." We like it the better for the added sentence: "It is recognised that this is a national issue." For that sentence makes it clear that the team is really considering eventual wholesale abolition, not one confined only to the diesel locomotive industry! The recommendation runs, of course, counter to trends of thought amongst many engineers in other sections of their industry. But it still reflects the fact that the number of real craftsmen in the engineering industry has declined, is declining and seems likely to continue to decline, unless action is taken to arrest the movement. It is, therefore, certainly possible that the adoption of some American practices, and more particularly that simplification of method referred to, may be forced upon manufacturers in this country through lack of the craftsmanship amongst their men to support more skilled methods of production.

There are, of course, many other less startling recommendations in the report. We do not refer to them here because they were fully summarised in our last week's issue. Moreover, many of them, directed though they are specifically to the diesel locomotive making industry, could be paralleled wholly or partly by very similar recommendations made by other teams in reports published earlier. For all the teams that have visited America have experienced there the same exhilaration from contact with industrial methods differing from their own, and have been stimulated thereby, and in relation to their own particular interests, to criticism of British methods. For our part we doubt, as we believe many engineers in this country doubt, whether, in fact, British manufacturers can benefit any more directly from observation of American methods designed to meet special marketing conditions than they could from studying the methods of their competitors at home and upon the Continent. But we do not mean thereby to depreciate the value of sending productivity teams to America. The real value of the reports these teams bring back lies in the stimulus they give to thought and the urge they can generate towards finding solutions to British problems by British methods.

Literature

Histoire de la Mécanique. By RENE DUGAS. Published by Editions Griffon, Neuchâtel, Switzerland. Price £5 15s. 6d.

THIS book contains so comprehensive an account of the evolution of the science of mechanics that it is impossible to do anything like justice to it in the course of a brief review. Within little more than 600 pages of text M. Dugas has covered the history of thirteen centuries of mechanical theory, from its beginnings in the civilisation of ancient Greece to the revolutionary conceptions of the last few years. He has made no attempt to deal with the development of actual mechanisms, but even so the field is immensely wide, for the ideas of mechanics underlie every branch of science that is concerned with matter and motion. The foundations of astronomy, optics and mechanics were, indeed, largely laid by the same men, whose discoveries so often proved of importance in directions other than those at first envisaged, that to distinguish between what is mechanics and what is not, is not always an easy task. This difficulty has been met by referring to all pertinent discoveries as far as possible in a chronological order, though interrupting the sequence when necessary to review the progress in a particular field.

Mechanical science made a bad start. Although Aristotle had correctly explained the principle of the lever, he taught that a continuously acting force was required to keep a body moving, and that the reason why a falling body increased in speed was because the force became greater as the earth was approached. The force supposed to be maintaining the flight of a projectile was attributed to the same cause that was invoked by Coleridge to drive the ship of the Ancient Mariner—"The air is cut away before and closes in behind." The need of a continuous force to maintain motion was denied by Philipon of Alexandria, in the seventh century, but his reasoning was of no avail against the traditional authority of Aristotle, which held its sway until at least the beginning of the fourteenth century, when William of Occam pointed out that the propelling power could not be continuously derived from the apparatus that launched the projectile, for that might be destroyed without stopping the flight, neither could it be derived from the air, for otherwise it would be impossible for two projectiles to have a head-on collision. About the same time another critic appeared in the person of Jean Buridan, Rector of the University of Paris, who is now remembered chiefly for the story of his logical donkey, which died of starvation when placed centrally between two equal bundles of hay. Buridan explained the sustained motion of bodies by their "impetus" or kinetic energy, as it would now be called. The notion of velocity as the rate of change of distance, and of acceleration as the rate of change of velocity, were put forward by William Heytesbury, Chancellor of Oxford University in 1371, nearly 300 years before the invention of the differential calculus enabled such ideas to be conveniently symbolised.

Very little progress, however, was really made in physical science until after the start of the fifteenth century, when the labours of men like Leonardo da Vinci, Copernicus, Galileo, Descartes and Huygens prepared the way for Newton to establish, in his *Principia*, a set of mechanical laws that were believed, until comparatively recent years, to represent the limits of attainable truth. Before that time the refraction of light had been studied by Descartes and Fermat, and the latter had announced in 1662 mainly on metaphysical grounds, that a refracted beam always took the quickest path from point to point. This gave rise to a long controversy, which finally led to the discovery by Maupertuis, in 1774, of the Principle of Least Action as a general law of Nature. During the next hundred years or so mechanical science was greatly advanced by Daniel Bernouilli, Laplace, Lagrange, Fourier, Gauss, Hamilton, and many others, and no reason arose to question the sufficiency of the Newtonian system until about the middle of the last century, when Leverrier noticed that it gave results which conflicted with the observed motions of the planet Mercury. The Newtonian system, which had stood the strain of substituting the wave theory of light for the corpuscular theory, and of replacing "caloric" by molecular motions, had finally to be regarded merely as an approximation to absolute truth after the famous experiment of Michelson and Morley in 1887. After this matters moved apace. Einstein's theory of Relativity, first published in 1905, not only accounted for gravitation, which Newton had never claimed to do, but also explained every observable fact when Newton's theory had failed. Then, in 1911, Rutherford showed that the atom, instead of being an impenetrable solid body, was proportionally as empty of matter as the solar system: and two or three years later Bohr showed how the planetary electrons of an atom emitted radiant energy in dis-

crete "quanta," each some exact multiple of the Universal Constant of Nature, discovered by Planck. The behaviour of electrons, on Bohr's theory, was irreconcilable with the notions of classical mechanics, and to get over the difficulty, de Broglie, in 1923, propounded the theory that electrons were not corpuscular bodies at all, but something in the nature of groups of waves. Schrödinger developed this idea and suggested that the groups were "waves of probability," and in 1925 Heisenberg propounded the "Principle of Indeterminacy," according to which it is impossible to know both the position and the velocity of an electron (whatever an electron may be) at any given instant.

Great as is the interest in the gradual evolution of the classical mechanical theory, the developments which take the strongest hold on our imaginations are those which have followed since Einstein changed the whole course of thought by his theory of Relativity, and Rutherford effected an equal revolution in our concepts of matter by his discovery of the constitution of the atom. M. Dugas has shown his appreciation of this fact by devoting more than a third of his book to the theoretical advances of the last forty-five years. The treatment of such a subject is necessarily very mathematical and is likely to be somewhat above the heads of engineers in general, but those who have been able to follow the tendencies of modern thought will be glad to have this authoritative survey of the lines along which it has developed. The volume as a whole constitutes a wonderful history of progress towards the understanding of the mechanics of Nature. The thoroughness with which it has been compiled will be evident from the fact that the index contains references to more than 400 philosophers and scientists, whose share in the development of mechanical science has been thought worthy of mention. In a preface to the volume, M. Louis de Broglie compares it favourably with the historical work of Ernst Mach and Pierre Duhem, and justly praises the erudition, critical ability and patience displayed by the author in the accomplishment of a monumental task.

The Properties of Asphaltic Bitumen. By J. Ph. Pfeiffer. London: Cleaver-Hume Press, Ltd., 1950. Price 45s.

Asphaltic bitumens are non-aqueous colloidal systems of very high viscosity, being mined in large quantities as native asphalts, and produced in still larger quantities as by-products of the petroleum industry. This volume presents the results of a series of investigations carried out in the Royal Dutch Shell Laboratory, Amsterdam. The data was compiled during the second world war and afterwards compared with and supplemented by data from other sources. It represents a comprehensive treatise on the subject of asphaltic bitumens and deals at considerable length with the constitution, chemical and physical properties, manufacture, testing and some applications of these substances. As the author points out, the application of asphaltic bitumen has developed mainly on empirical lines and quantitative analyses of the constructional problems involved in many of these applications are still lacking. In connection with some of the chief applications of this material, such as bituminous road building, much progress in analysing problems of construction is being made, but present knowledge of the relation between properties and actual performance of bitumens is still very much of a qualitative nature. The book does not attempt to outline in detail all, or even the main applications of bitumen, and the discussion of applications is confined for the most part to instances which exhibit most clearly the properties of the bitumen. For example, the use of compositions the properties of which are not primarily determined by the bitumen contained in it, but rather by the combined properties of bitumen with other materials—such as road-making mixtures—are not dealt with in detail. For the benefit of readers who require such information, however, reference is made to other available literature. In surveying the properties which are of major significance for the applications of asphaltic bitumens, the author divides the properties of bitumens and asphalts into three categories for the discussion of their significance in such applications as road and runway construction, protection of dams, sea and river banks, &c., roofs, walls and floors of buildings, roofing felts, tiles, flooring, &c. These three categories are those governing processibility or workability, those having a direct bearing on the primary functions which the bitumen or asphalt has to fulfil, and those determining the performance of the bituminous construction in relation to time under the external conditions to which it is exposed. In considering the applications of asphaltic bitumens, Dr. Pfeiffer appreciates that in many cases the bitumen forms only a minor constituent of the final object. Thus the ultimate performance of such an object may be governed in equal measure, or even, chiefly, by the properties of the materials to which the bitumen is applied or with which it is combined. Road-making is a typical example, since the properties of the mineral aggregate, the design of the foundation, good workmanship, &c., are at least as important as the properties of the bitumen. The book presents an excellent outline of the knowledge so far obtained on the fundamental properties of asphaltic bitumens, in the building up of which scientific investigation and practical experience have gone hand in hand. This combination of theory and practice is a typical feature of materials research, which finds both its incentives and its ultimate aims in the performance of these materials in practice. While much of this volume is likely to be of interest chiefly to chemists, it presents information which is of value to the civil engineer and others concerned with structural materials in which bitumen is a constituent. In compiling the work, the author has had the assistance of other research workers in the oil industry and the data presented is derived mainly from their researches. After reading the book one is inclined to agree with the author when he says that the great progress made during the last twenty years holds out fair promise that the technology of bitumen will cease to be an art and become a science in a not too distant future.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

REACTIVE FORCE IN A TURBINE NOZZLE

Sir,—In the review of "Steam and Gas Turbines," by Skrotzki and Vopat, in The Engineer of November 3rd, your reviewer takes exception to a statement made by the authors of the book. I quote from your review:

". . . In an effort to achieve simplicity they have explained that the reactive force of a steam-jet is equal to its 'unbalanced force' and have illustrated their argument by a picture of a cubical box supplied with high pressure steam, which escapes as a jet from a convergent nozzle in one of the side walls. With steam at 120 lb per square inch and a nozzle area of 1 square inch, the reactive pressure on the box is said to be 120 lb."

Your reviewer goes on to say:—

"This may seem plausible, but it is, unfortunately, altogether wrong. The reactive force is due, of course, to the change of momentum of the steam and a simple calculation will show that it could not, even theoretically, exceed about 76 lb in the case considered."

It would appear that there is an underlying error in both of the statements quoted above, neither of which gives any indication that the true value of the reactive force should be in the region of 240 lb. For an incompressible fluid like water the reactive force would have exactly this value, namely, 240 lb. For an elastic fluid like steam the value would be less but still greater than 120 lb. It is difficult to understand how the figure 76 lb, quoted by your reviewer, was obtained.

A. C. Hutchinson

Bedford, December 5th.

[The reactive force of any jet is measured by the change of momentum that occurs in the fluid. In the case considered saturated steam at an absolute initial pressure of 120 lb was assumed to remain in a state of thermal equilibrium during its expansion. Under such conditions the pressure at the throat of the nozzle would be $120 \times 0{\cdot}577 = 69{\cdot}24$ lb abs., as is explained in all the textbooks. The corresponding heat drop would be 43·9 B.Th.U., which would produce a jet velocity of 1482ft per second. Allowing for the wetness of the steam at the throat, its specific volume there will be about 6·08 cubic feet per pound, so that we have a mass-flow of about 1·65 lb per second, which, at the velocity given, creates a reaction of just about the 76 lb mentioned in the review. Since experience has shown that, in practice, a well-formed convergent nozzle will actually discharge a few per cent more steam than is consistent with the assumption of stable conditions during its expansion, it is now more usual for designers to abandon this theory and to assume that expansion follows the law of superheated steam ($PV^{1.3}$ = constant) and that consequently the steam is in an unstable super-saturated condition during its expansion. If this is so, the ratio between the throat pressure and the initial pressure becomes 0·546 instead of 0·577, so that the throat pressure would be 65·5 lb in the case considered. The mass-flow would become 1·786 lb per second at a velocity of 1528ft per second, which would give a reaction of 84·7 lb instead of the 76 lb on the older theory.—Ed., The E.]

BOOKS RECEIVED

Maschinenelemente. By Dr.-Ing. G. Niemann. Berlin: Springer-Verlag, Reichpietschufer, 20. Price Dmk. 28·50.

Lehrbuch der Bergwerksmaschinen. By Dr. H. Hoffmann. Berlin: Springer-Verlag, Reichpietschufer, 20. Price Dmk. 36.

The Motor Ship Reference Book. Nineteenth edition. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 15s.

Year Book of the Heating and Ventilating Industry. London: Technitrade Journals, Ltd., 8, Southampton Row, W.C.1. Price 7s. 6d.

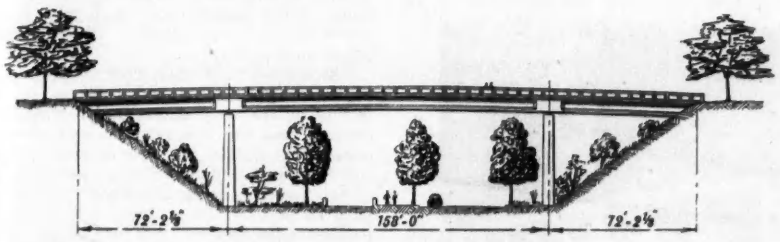
Electrical Installation Work. By T. G. Francis. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 12s. 6d.

The Identification of Molecular Spectra. By R. W. B. Pearse and A. G. Gaydon. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 50s.

Principles of Aircraft Propulsion Machinery. By Israel Katz. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

The Walnut Lane Bridge at Philadelphia

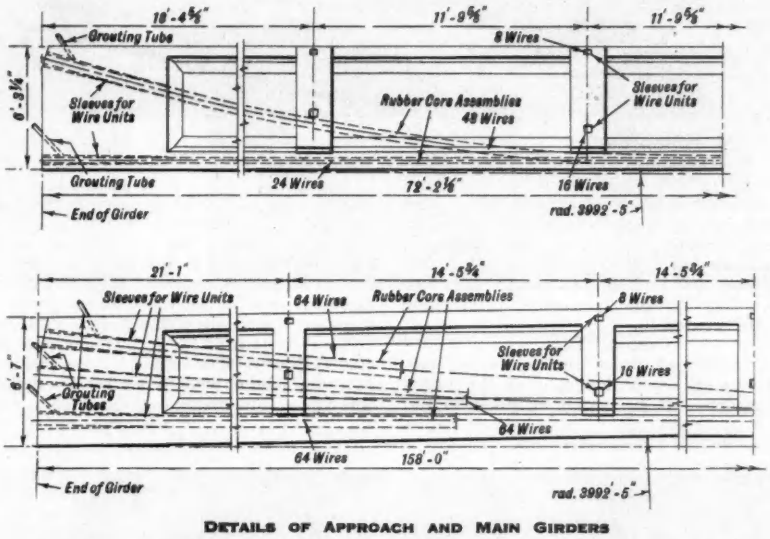
COMPLETION is approaching of the Walnut Lane Bridge over the Lincoln Drive at Philadelphia, the first prestressed concrete deck girder bridge to be constructed in the United States. The bridge consists of a 158ft central span and two 72ft 2½in approach spans. It has a 44ft-wide roadway, surfaced with a 1in layer of asphalt plank paving and two footpaths, approximately 9ft wide. Early designs for a prestressed concrete bridge at the Walnut Lane site were based on a continuous span box-girder type of structure, using steel cables as the prestressing element. This design, in which the cast-in-place box-girders made up the full length and width of the bridge, precluded the testing to failure of any essential element, a procedure which was considered essential by the engineers representing the City of Philadelphia. The present design involves thirteen precast flanged girders, 6ft 7in deep in the central span and seven similar girders in each side span. Instead of cables, the final design adopted utilises single-strand prestressing wires. The wires being used are 0·276in in diameter and have an ultimate tensile strength of 210,000 lb per square inch, with a yield strength of 160,000 lb per square inch at 0·2 per cent permanent set. They are prestressed to 125,000 lb per square inch and the final stress, after shrinkage and plastic flow of the concrete and creep of the steel have taken place, is in the region of 105,000 lb per square inch. The concrete is specified to have a twenty-eight-day crushing strength of 5400 lb per square inch. Initial prestressing of the concrete is taken to a maximum of 2000 lb per square inch, making the working stress approximately 1800 lb per square inch. On the assumption that there will be a gain of 30 per cent in the strength of the concrete before the bridge is opened for service, the factor of safety is about 4.



ELEVATION OF WALNUT LANE BRIDGE

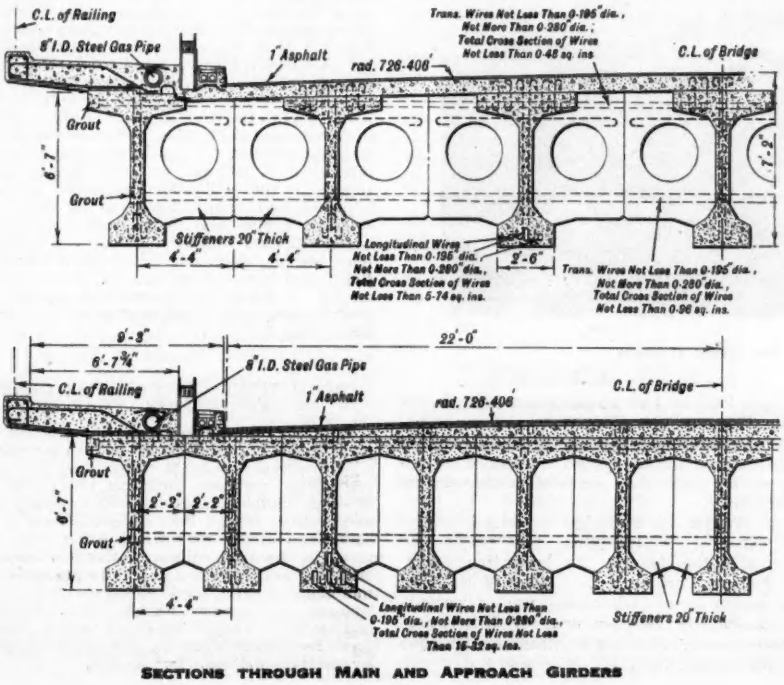
Each one of the 160ft girders in the Walnut Lane Bridge weighs 135 tons, which would have presented a serious transportation and placement problem should the girders have been cast at a distance from the site. During the design stage this possibility was contemplated and many hoisting rigs were designed and considered. However, the contractor elected to cast the girders on top of the 50ft piers, one or two at a time, using falsework to support the moulds.

Before concreting, the rubber sleeves forming the housings for the longitudinal prestressing wires are placed in units in the bottom flange of the girder moulds; four units in the 160ft central girders and three in the approach spans. The arrangement and position of the wires are predetermined so that the prestressing force will act with its greatest eccentricity at the centre of the span, where the moment is greatest, and will decrease to zero eccentricity at the supports. The four wire units in the main span contain sixty-four wires each, a total of 15·3 square inches of steel; in the approach spans two units contain twenty-four wires and one forty-eight wires, a total of 5·8 square inches of steel. Each unit is enclosed in a sectional steel sheath about 2½in by 8in in cross section. The wires in a unit are positioned in their sheaths by mild steel spacers located at intervals so that the wires are nowhere closer than ⅛in from each other or from the inside surface of the sheath. In the main span, two sheaths containing wire units, are set in the moulds horizontally and two sheaths curve upward from the low centre position along a predetermined rising parabola to extend beyond the ends of the girder. In the approach spans only the forty-eight-wire unit is curved upward from the centre of the span.

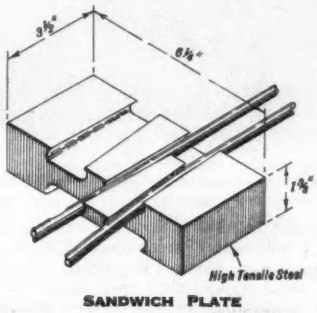


DETAILS OF APPROACH AND MAIN GIRDERS

After the concrete in a girder is poured and cured, the wires are inserted and prestressed in pairs by specially designed hydraulic jacks. Each pair of wires is fitted into a tapered slot in a flat steel sandwich plate. Each 1⅛in by 3½in by 6½in sandwich plate holds four pairs of wires and rests on edge against a distributing plate bearing on the concrete at the end of the girder. After the wires are stressed, flat steel wedges are driven into the slots to lock one wire against each side of the slot. Thus, any pressure exerted against one wire of a pair reacts on the other with equal locking

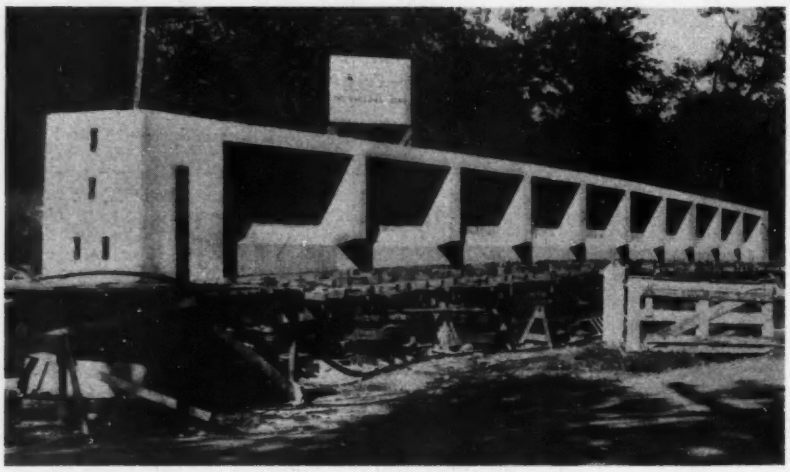

C.L. of Railing
8"I.D. Steel Gas Pipe
1"Asphalt
rad. 726-406'
Trans. Wires Not Less Than 0-195" dia., Not More Than 0-280" dia.; Total Cross Section of Wires Not Less Than 0-48 sq. ins.
C.L. of Bridge
Grout
6'-7"
Grout
7'-2"
Stiffeners 20" Thick
4'-4"
4'-4"
Longitudinal Wires Not Less Than 0-196" dia., Not More Than 0-280" dia., Total Cross Section of Wires Not Less Than 5-74 sq. ins.
2'-6"
Trans. Wires Not Less Than 0-195" dia., Not More Than 0-280" dia., Total Cross Section of Wires Not Less Than 0-96 sq. ins.
9'-8"
6'-7¾"
22'-0"
8"I.D. Steel Gas Pipe
C.L. of Railing
1"Asphalt
rad. 726-406'
C.L. of Bridge
Grout
6'-7"
Grout
2'-2"
2'-2"
4'-4"
Longitudinal Wires Not Less Than 0-196" dia., Not More Than 0-280" dia., Total Cross Section of Wires Not Less Than 15-32 sq. ins.
Stiffeners 20" Thick

SECTIONS THROUGH MAIN AND APPROACH GIRDERS



SANDWICH PLATE

pressure. In addition to the mechanical lock of the wedges in the sandwich plates, the wires are bonded together by grout, which is forced into the wire sheaths until they are filled. After prestressing, the end bearing plates and the sandwich plates and their wedges are grouted in to protect them from the weather. On completion each girder is moved laterally into final position on the piers. When all the girders are in place they are pulled together laterally by transverse prestressed wire units running through the top and bottom of the diaphragms and spaced about 14ft 6in apart in the main span and 16ft apart in the approach spans. Finally, the transverse prestressing wires are grouted in.



TEST GIRDER AFTER REMOVAL OF SHUTTERING

Girder Test

The prestressed girder used for testing purposes was an exact duplicate of the bridge main girders. It had been intended to test the girder to destruction by distributing a load of 360 tons of steel ingots at eight points of application along the girder, simulating a uniform load of 5200 lb per foot. However, actual material properties proved superior to initial design values; the wires showed a yield point of 213,000 instead of an expected 160,000 lb per square inch and the twenty-eight-day concrete strength was 7200 instead of the anticipated 5400 lb per square inch. Professor Magnel, who attended the tests, accepted the blame for the "lack of destruction," explaining that he had not expected to find that wire and concrete of such high quality would be available in the United States.

After the girder had been prestressed the compressive stress in the bottom flange was 2000 lb per square inch and in the top 1050 lb per square inch. The first test load added to the 300,000 lb deadweight of the girder, was an increment of 110,000 lb, representing the working or design live load of 750 lb per foot, plus 40,000 lb to account for the dead load of later paving, &c. Under this total load of 410,000 lb the deflection was $\frac{3}{4}$in. The next loading increment was double the working load and produced a deflection of $1\frac{1}{2}$in. The first visible crack appeared after an additional 44,000 lb was added, or under a total load, including the weight of the girder, of 524,000 lb and a deflection of $3\frac{3}{4}$in. Increments of about 40,000 lb were then added by the jacks until at a total load of 3000 lb per foot the deflection was $5\frac{3}{8}$in. It increased to $10\frac{3}{4}$in under a 4200 lb per foot load and to $15\frac{3}{8}$in under 5000 lb per foot. The test was stopped at this point because of insufficient weight in the loading frames to ensure breaking the girder, but failure, as evidenced by extensive vertical cracking, had occurred.

CRACKED BOTTOM FLANGE OF TEST GIRDER

The Walnut Lane Bridge is being built for the City of Philadelphia, the prestressed portions of the structure being constructed by the Preload Corporation, of New York City. The design employed makes use of patents owned by the Belgian firm of Enterprises Blaton-Aubert, with which Professor Gustave Magnel is associated.

Ceramic Tipped Tools

CERAMIC tipped tools have been used successfully for some time for machining highly abrasive materials which do not require a heavy cutting face to remove the chips. This type of tool is made by B.S.A. Tools, Ltd., under the trade name "B.S.A.-Sintrex," and is now being marketed by Burton Griffiths and Co., Ltd., of Montgomery Street, Birmingham, in a number of forms for boring, turning and milling operations on highly abrasive materials such as plastics, fibres, graphite, asbestos, &c.

The makers state that wear on the top faces of these types of tipped tools is negligible during cutting operations under normal conditions, and the non-metallic and chemically unreactive nature of the ceramic precludes the building-up and welding on the tool tip of the material being machined. The ceramic used has a very low coefficient of friction and its thermal conductivity is said to be half that of tungsten carbide. The heat generated during cutting is repelled by the tool tip, where it normally causes wear, and acts as a softening agent on the swarf. This heat in softening the swarf serves to assist in the cutting action of the tool.

The makers state that when using ceramic-tipped tools the peripheral turning and boring speeds should generally be as high as possible, as speed does not have any detrimental effect on the tools. The depth of cut can be as great as possible consistent with satisfactory swarf removal. Although it has been found preferable to use the tools without any cutting fluid, if a liquid is essential it should be flooded on to the point of cutting. In general rake angles slightly less than those employed for normal tool materials are used for the ceramic-tipped tools, and when cutting plastic materials clearance angles of about 6 deg. with a secondary clearance of 8 deg. are suitable. When grinding the tools diamond wheels should be used if possible.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

SLIP (OR BLOCK) GAUGES AND THEIR ACCESSORIES

No. 888 : 1949. This British Standard was first issued in 1940 and forms one of a series of specifications published or in course of preparation, for engineers' precision tools. It deals with the parallel-faced type of gauge, which was first introduced by Messrs. C. E. Johansson about forty-five years ago and which has for many years been manufactured in Great Britain by a process developed by the National Physical Laboratory. The present revision of this standard makes provision for slip gauges of the "reference" grade of accuracy in addition to the three grades, namely, workshop, inspection and calibration, to which the previous standard referred. The reference grade has been introduced in response to a demand for gauges similar to the calibration grade but with sizes adjusted even more closely to nominal. This standard applies also to the commoner types of accessories used with such gauges, viz., measuring jaws, scribing point and centre point holders (or slides) and base. Requirements are set down in respect of design, dimensions and accuracy and recommended sets of gauges are given in an appendix. Price 3s.

CARBON STEEL CASTINGS FOR GENERAL ENGINEERING PURPOSES

No. 592 : 1950. This standard is a revision and an extension of the one issued in 1940 and provides a comprehensive range of carbon steel castings for engineering purposes, including the construction of ships, marine engines and railway rolling stock, and replaces B.S.24, Part 4, Specification No. 10. The three grades of castings differ from those given in the 1940 edition of the specification in that they are of 28, 32 and 35 tons per square inch minimum ultimate tensile stress, and full chemical composition is specified for all grades. Inspection and testing is covered in detail and an appendix gives recommendations on the repair of castings by metal-arc welding. 2s. post free.

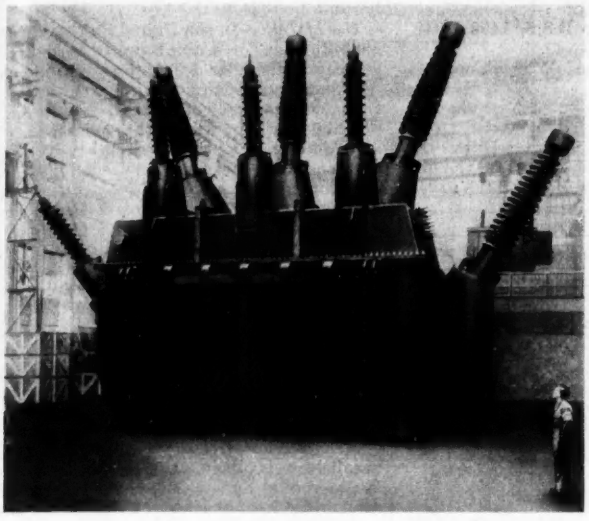
A 230kV Transformer for Finland

PREPARATIONS have been completed at the new transformer factory of Ferranti, Ltd., Hollinwood, for shipment of what is believed to be the first three-phase 230kV power transformer to be exported from this country. The transformer is the first of five similar units which Ferranti, Ltd., has on order for Finland, and it is to be installed at the Pyhakoski generating station of the Imatra Power Company.

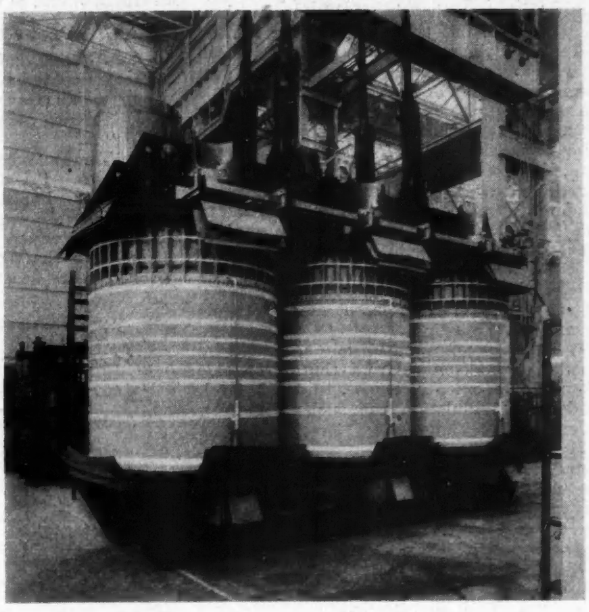
Three windings are provided on the transformer, rated respectively for 64/64/32MVA, the voltage ratios being 115·5/231/10·5kV between phases. Both the 115·5kV and 231kV windings are star connected with the neutral ends fully insulated. The 32MVA, 10·5kV winding is used to supply three 10MVA reactors to compensate for the capacitive load of the 220kV transmission lines. The transformer is rated for the full loadings to be applied on all windings simultaneously. Tappings are provided on the 115·5kV windings for off-circuit changing by hand-operated tapping switches. The transformer is designed to British standards in all respects except for pressure tests, which are in accordance with Swedish rules. To meet these pressure test requirements, the 231kV windings were designed for and tested at 530kV, 50 c/s, which is claimed to be the highest 50 c/s test voltage applied in this country to a transformer, either single-phase or three-phase, from a separate source. The test voltage on the 115·5kV windings was 275kV, 50 c/s.

The transformer is a ON/OFB unit, cooling being provided by forced oil circulation and two banks of air-blast-cooled radiators adjacent to the transformer itself. Use is made of the Ferranti system of directed oil flow, in which the cooling oil, entering at the bottom of the tank, is not discharged into the general volume of oil but is led directly into the end clamps. From these clamps the oil is fed into a distribution chamber, whence it is discharged into the axial ducts of each winding in predetermined proportions. The axial ducts are provided with oil directing barriers so that the oil flows alternately from the inner to the outer duct and then from the outer to the inner through the radial winding ducts. This positive flow through the radial ducts reduces the difference in temperature between the windings and oil and the rise in oil temperature between inlet and outlet remains uniformly low in all windings, the difference between the mean oil temperature and maximum oil temperature in the transformer tank being only 2 or 3 deg. Cent. at full load. In consequence, the hot-spot temperature of the OFB transformer is only 3 or 4 deg. Cent. higher than the temperature as measured by resistance of the windings. The ON rating of the transformer is 66⅔ per cent of the OFB rating.

The transformer in its tank, complete with bushings but exclusive of the radiator banks (as illustrated), is 30ft high, 35ft 3in long and 11ft broad, the weight including oil being 176 tons. The service dimensions, including radiator banks and cooling gear, are 30ft high, 51ft 3in long and 28ft broad. Although there is no difficulty in lifting the complete transformer at the Ferranti factory, the present limit in lifting capacity at the port of Abo, Finland, and of rail transport in Finland, is 90 tons and, for shipment, it is necessary to dismantle the transformer into units which do not exceed this limit. The core and windings are shipped in a special transport tank, which is built round them and hermetically sealed; the actual service tank and service cover are each shipped separately. Special routing has been necessary to avoid bridges between the works and Manchester Docks, where the transformer was loaded for Finland, and at one spot it was necessary to raise the trolley wires, where the route to the docks crosses the route of a trolleybus service. Separate shipment of the main tank and service cover was required in order to clear G.P.O. telegraph wires *en route* to the docks. In Finland the journey from Abo to Pyhakoski will be made by rail, using special trucks, to suit which the transformer tank has been shaped. The final tanking and assembly with the necessary vacuum filling will be carried out on site by Ferranti engineers.



230-KV TRANSFORMER FOR FINLAND



WOUND CORE OF TRANSFORMER

Technical Reports

Recommendations for the Metal Arc Welding of Butt Welds in Steel Pipe-lines for Power Plant. British Welding Research Association, 29, Park Crescent, London, W.1. Price 2s.—The welding of circumferential butt joints in pressure pipelines by the metal arc process involves special techniques to ensure consistent penetration and root fusion. Two main methods are available: the first method involves the use of a backing-ring, which may be retained as part of the final joint, or may be removable, and the second method involves the use of a base run of welded metal deposited by the oxy-acetylene process. The methods given in this memorandum are the best generally available at the present time, but there are indications that the adoption of special techniques or specially trained workmen may enable backing-rings or oxy-acetylene base runs to be dispensed with. Any such proposal should be very carefully investigated to verify that welds made in all positions will pass consistently the test requirements of this memorandum.

The recommendations are applicable to butt welds in pipe-lines of wall thicknesses from 8 s.w.g. and of diameters exceeding 2in outside diameter. By the methods recommended, pipe-lines varying from these limits up to 13in outside diameter and wall thicknesses reaching 1¼in have been successfully constructed for working pressures up to 2000 lb per square inch and working temperatures of 540 deg. Cent. (1000 deg. Fah.). Butt welds in piping of similar sizes and for similar conditions have also been constructed by the oxy-acetylene process throughout (see Memorandum T.5, also published by the British Welding Research Association). The recommendations are based on the manufacture of many pipe-lines for a variety of service conditions, together with large numbers of tests on joints, carried out by members of the FE.10 Committee.

The Breakdown of Dielectrics by Electric Discharges (Ref. L/T191). By A. Morris Thomas, B.Sc., A.M.I.E.E., F.Inst.P. The British Electrical and Allied Industries Research Association. Price 13s. 6d., postage 3d.—Continuing the work described in Ref. L/T137, the present report gives an account of the further investigation into the process of electric strength deterioration in solid insulating materials subjected to electric discharges or corona. Little progress has been made in the solution of the fundamental problem of the mechanism of the process and of the resulting breakdown, as it was not possible to detect the onset of breakdown. It has been shown, however, that the breakdown process starts and is completed in a very short interval of time.

The report contains, first, an account of experimental tests made for the purpose of determining the effect of variables such as size and B.D.V. of the discharge gap, applied voltage, ambient relative humidity and electrode shape. Secondly, further exploratory experiments were made with a view to higher precision in adjusting the discharge gap and control or measurement of the discharge "intensity." These consisted of tests with a new design of electrode system in a circuit incorporating meters for measurements of the discharge current transients and a gas-filled triode relay circuit. To assist interpretation of the results, an analysis of the test circuit was made and the results compared with measurements made with a model electrode system. Thirdly, measurements of the B.D.V. of a discharge gap bounded on one side by a dielectric were reported and compared with the B.D.V. of a metal bounded gap. Materials tested were black and yellow varnished cloth, as well as cellulose acetate, polythene and polyvinyl chloride sheets.

Naval Gearing—War Experience and Present Development*

By Cdr. (E.) J. H. JOUGHIN, D.S.C., R.N., A.M.I.Mech.E.†

Introduction

All but a few of the high-powered naval ships in service during the 1939–45 war were fitted with turbines driving through gearing. The successful use of gearing in the Royal Navy at the end of the 1914–18 war (Tostevin, 1920), and subsequently in merchant ships, gave little reason to expect that it would not be absolutely reliable, but two years of war failures showed that where standards of accuracy fell below the average for the country no positive margin of safety remained.

A thorough examination to which many persons have contributed has revealed the main causes of these failures. Apart from remedying them, it has been possible to make some immediate advances in design and production standards, to employ stronger materials, and to undertake development work in the expectation that it will provide worthwhile advances.

Lessons Learnt

The principal lessons learnt from wartime experience are :—

(1) To keep noise and vibration, caused by periodic errors coming from the worm-table drives of non-creep machines, to a safe level, the depth of undulation from such errors must not exceed 0·0003in.

(2) To eliminate the risk of scuffing and pitting, load must be transmitted by at least two-thirds of the working surfaces of the gears. This may be ensured by keeping the surfaces free of undulations of more than 0·0001in range.

(3) To eliminate the risk of scuffing, pitting and breaking, the relative helical angles of pinion and wheel, the parallelism of their axes in the gearcase bearings, and the freedom from cross-wind of the gearcase must be measured and controlled.

(4) The effect of pinion deflections in concentrating the load at the outer ends of the helices was critical. Through lack of an earlier quantitative evaluation of this effect, the maximum loading at the ends had been higher than would have been experienced on a pinion of two-thirds the face width. The value of maximum local loading must provide the basis of design.

(5) While pitting was unimportant, scuffing was a great nuisance, though it fortunately did not necessitate replacement of the gears. Breaking of the teeth at the root, however, could be disastrous. Reliability in this respect is of paramount importance.

Standards of Accuracy Essential for Reliability

Experience in the fields of automobile and aircraft gearing (Mansion, 1940, 1941 and 1942) has assisted in setting the present standard of production and resulted in improved reliability.

Surface Quality.—Research to investigate the conditions in the oil film between teeth and the effects on scuffing and surface pitting is now in progress.

Already, from full-scale experience and from disc testing, it is clear that any undulation of less than ¼in wavelength, and more than 2×10^{-5}in deep, leads to local areas of increased heat generation and of increased stress, and hence to a reduction in reliability.

Alignment.—The additional loads due to misalignment and to undulations of long wavelength can be roughly estimated.

Where the combined deflection of the engaging teeth under a load of 1000 lb per inch of face width is 0·0004in, an error of 0·001in over the face in helical angle, or in parallelism of the shafts perpendicular to the common plane, will entail a difference in load between the ends of 2500 lb per inch of face width, and an increase in the maximum loading by 1250 lb. per inch of face width. A long undulation due, for example, to a daily band of 0·0004in depth will impose an increase in the maximum local loading of 500 lb per inch.

With a fine surface finish and the present soft materials wear does not correct helical angle errors, daily bands, or the strain due to pinion deflection under load (Monk, 1949). Stronger materials, in general, provide an increase in resistance to wear greater than the simultaneous increase in resistance to root failure (Almen and Straub, 1937, and Mansion, 1940).

It is evident that economical use is not being made of gears until their alignment, as meshed in the bearings, is within 0·0005in.

Production Equipment

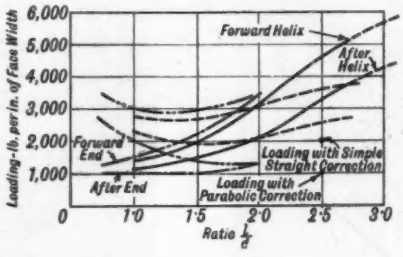
Gear Cutting and Finishing.—To obtain the necessary standards of accuracy, essential requirements (Davis, 1949) are :—

(1) Hobbing machines to B.S.S. 1498 : 1948, grade "A."

(2) Temperature control of machine and cutting, to ±1 deg. Fah.

(3) A post-hobbing process, such as shaving or lapping.

Such equipment is now in limited use. In some cases the permissible errors on the as-hobbed gears according to B.S.S. 1498 : 1948



Values of maximum local load with:

Total load equal to that with mean load of 1000 lb per in on l/d of 2·0 { —·—·—·— Single helical; — — — — Double helical

Mean load of 1000 lb per in { —·—·—·— Single helical; ———— Double helical

With an l/d ratio of 2·5, where l is the effective face width, and d the pitch circle diameter, the maximum loading with simple straight correction would be 2000 lb per in, and with parabolic correction 1000 lb per in. With the same l/d ratio the maximum loading for uncorrected pinions would be 4500 lb and 3300 lb per in on the forward and after helices respectively.

Ideally the helix angle should be continuously varied over the whole width, this being referred to as parabolic correction. An approximation to this may be obtained by two or more steps in each of which the helical angle is kept constant ; this is known as straight correction.

Fig. 1—*Load Concentration on Single and Double Helical Pinions*

(clauses 41, 42 and 43) have been halved. Shaving or lapping has then improved the surface and corrected slight differences in helical angle between the pinion and wheel.

Grinding provides similar accuracy and finish.

For this correction and for a close control of helical angles two further items are essential : the axial pitch gauge (Timms, 1947) and an accurate meshing frame.

With this equipment and skilled craftsmen it appears practicable to maintain a match of helical angles of pinion and wheel to within 0·0003in.

No quantitative control of profile on large gears is practised at present.

Alignment in Gearcases.—Dimensional accuracy in the production of marine gears and their gearcases is of prime importance, and the achievement of such accuracy has been due, in the main, to the development of new measuring apparatus. The undulation recorder at once made a great improvement in quality of the product, and the axial pitch gauge and meshing frame are making another. The development of means to assess the accuracy of alignment of gears and gearcase assemblies is still in the initial stages.

Present Practice.—Double helical gears are hobbed, shaved, and meshed in a meshing frame. The pinions are selectively shaved to the wheel.

Single helical gears are ground, and meshed in a meshing frame. The pinion helical angle is reground to match the wheel.

Meanwhile the gearcase has been bored. When mandrels, levels and stick gauges are used the error in measuring the parallelism of the bores may be up to 0·002in. With improved equipment this should be reduced to 0·001in.

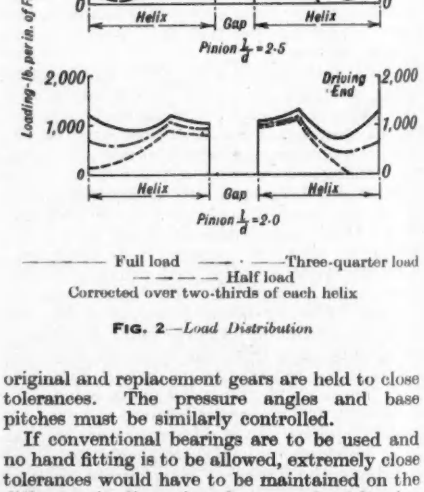
The bearings are fitted to the gearcase and the gears placed in them. Marking is then applied to the gears and one of the pinion bearings is adjusted to give the best meshing, which will provide alignment within perhaps 0·0003in to 0·0005in over the face. Should any bearing have to be replaced, the same meshing test and adjustment is carried out. This meshing test is at present the most accurate check of the parallelism of the axes of the gearing elements in their bearings and of the bearing bores.

Use of Jigs.—In the United States during the 1939–45 war, for a number of "locked-train" gearcases of similar design, jigs were in general use, and much setting-up time was thus saved, though the accuracy of parallelism of boring was no higher than with other methods. Two attempts are now being made to save setting-up time and, in addition, to bore to a higher degree of accuracy with jigs.

When jigs are used the first essential is to set them up in the correct relative positions, free from cross-wind, and the second is to employ adequate steadies correctly aligned. These steadies may be mounted on the gearcase itself. The alignment of the steadies may be checked by means of an alignment telescope and targets, and after boring the results may be measured by the same means. A recent test showed that the tolerances required in locked-train gears, to ensure even sharing of the load between the trains ahead and astern, have been obtained, and that the accuracy of measurement of parallelism is about 0·0005in. Development is proceeding and may later provide a check measurement of the bores as accurate as that provided by the meshing.

Interchangeability.—As gears are produced to such high standards of accuracy, the possibility of achieving interchangeability has assumed importance. In the event of failure of the gearing, interchangeable parts may be replaced with no hand fitting. The alternative is to allow an adjustment of one of the bearings to provide true meshing, the adjustment being done preferably in a controlled manner (Dayton and Allen, 1949), using a fixture for boring—or by a pad and adjustable liner behind the shell as in the steam gunboat pinion bearing.

In either case, with double helical gears, where it is desired to replace only one of a pair of meshing gears, provision must be made to ensure that the included helical angles of the



———— Full load —·—·— Three-quarter load
— — — — Half load
Corrected over two-thirds of each helix

Fig. 2—*Load Distribution*

original and replacement gears are held to close tolerances. The pressure angles and base pitches must be similarly controlled.

If conventional bearings are to be used and no hand fitting is to be allowed, extremely close tolerances would have to be maintained on the difference in dimensions between the following features, in pairs, for any one pinion or wheel : journal diameters, bearing bores, bearing shell

* Institution of Mechanical Engineers, December 15th. Abstract.

† Cdr. (E.) Joughin is at present serving in H.M.S. "Ceylon."

thickness, bearing outside diameter, and bearing housing diameters.

All these tolerances, except for that of bearing housing diameters, could be provided now, but the tolerance on the parallelism of the bores of the gearcase housing would have to be reduced to about one-third of the best achieved to date.

For the present, therefore, adjustment of the bearings by hand in initial production, and on fitting spares, must be accepted.

Freedom from Cross-wind.—The freedom from cross-wind of the gearcase has been checked by the use of an alignment telescope on an accurate rotary table, the departures from a plane of targets on selected positions also being checked. It is not yet clear whether this method will control the cross-wind to the degree of accuracy required.

A gearcase is being designed which will have the torsional stiffness requisite for mounting on three local areas. In view of the adverse working conditions under which the checking of gearcases is undertaken in wartime, the ability to dispense with the difficult check on cross-wind would be welcome.

This summary of present practice indicates that the standards required to maintain surface quality and the correct helical angles of the gears are being met. The alignment of the gears in the gearcase bearings depends generally on the skill of individual craftsmen.

Materials and Alternative Methods of Production

In the field of small gearing several methods of producing heat-treated steel gears are in use. Three of these methods may be used in the production of large marine gears, namely :—

(1) Hobbing and shaving the already heat-treated material. Shaving of material up to 80 tons per square inch ultimate tensile strength has been accomplished, though this may exceed the economic limit.

(2) Cutting and grinding the already heat-treated material. Steel of 80 tons per square inch ultimate tensile strength similar to EN.30 has been used for gear wheel rims finished in this way.

(3) Hobbing or cutting, case-hardening and grinding. Steel similar to EN.36 has been used for 70in diameter gear wheel rims.

Until recently the use of a medium-carbon steel for gear wheels was justified on the grounds that wheel teeth wear could relieve errors in alignment or, alternatively, by local yielding at the root, avoid fatigue failure. Experience of bruised teeth and knowledge of the increased yield strength of carbon steel at rapid rates of loading has shown that neither of these safeguards really exist.

The primary quality required of gear materials is resistance to failure by fatigue in bending under the stress concentration to be found at the root—say, 1·3 to 1·7. Another desirable quality is resistance to pitting and wear. This latter is, in general, a measure of the hardness (Merritt, 1934).

With regard to resistance to fatigue in bending, data from full-size specimens is difficult to find (Battelle, 1941), and tests are now going on by A.V G.R.A. to provide further information on typical steels.

As freedom from tooth failure by root fracture is the primary requisite, the justification for a difference of allowable loading between naval and merchant ship gears, based on difference of hours running at full power, disappears. Neither type of ship can afford such failures. A difference in standards of production would be the only possible justification for different loading standards.

An increase in root strength of hobbed and shaved gears may shortly be obtained by skin hardening through induction heating, using a steel of adequate carbon content. This process should not incur excessive distortion. It is not yet available for production, however. With small gears this method of surface hardening does not produce an increase in operating strength comparable with that obtained with the same increase of hardness in a through-hardened steel, but with large gears experience suggests that the converse is true. Increased interest in the processes of case-hardening and grinding resulted. For gear wheels too large in diameter for case-hardening, air-hardening steel could be used, but grinding would still be necessary.

The inherent possibilities and limitations of the two techniques, of hobbing and shaving heat-treated steel, and of case-hardening and grinding, have thus become prominent. It will be of value to examine two current designs of similar power using these two techniques, and loadings based on existing experience, and the production development and testing work now being undertaken to maintain production standards.

The ability of each technique to provide the corrections necessary to ensure even distribution of loading on pinions under strained conditions, and to safeguard against high loading at the ends due to disturbance of alignment caused by slight wear of bearings, will also be considered.

Recent Designs.—Two alternative designs have been accepted for a ship in which the gearing is a significant part of the machinery weight. These are :—

(1) Double helical, hobbed and shaved.

(2) Single helical, case-hardened and ground.

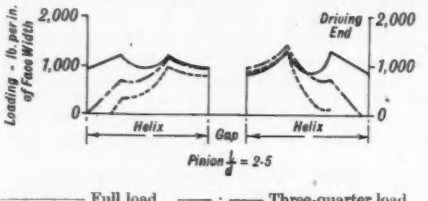
The first of these relies on fulfilment of the basic requirements of close temperature control,

Table I.—*Details of Some Marine Gears of Recent Design*

	Hobbed and shaved		Hardened & ground		Design (1), hobbed and shaved		Design (2), hardened & ground		Steam gunboat			Test gear, primary reduction	Test gear, secondary reduction
	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	As designed	Straight correction	Parabolic correction		
Type and pressure angle									Standard, 20 deg.	Standard, 20 deg.	Standard, 20 deg.	Standard, 20 deg.	Standard, 16 deg. 35 min.
Pitch (normal), in									0·618	0·618	0·618	1·047	1·496
High-pressure pinion, s.h.p.									4,000	8,000	8,000	12,000	12,000
Low-pressure pinion, s.h.p.													
High-pressure pinion speed, r.p.m.									5,000	5,000	5,000	6,000	1,500
Low-pressure pinion speed, r.p.m.													
Wheel speed, r.p.m.									900	900	900	1,370	283
High-pressure pinion pitch circle diameter, in									7·35	7·35	7·35	8·186	13·25
Low-pressure pinion pitch circle diameter, in													
Wheel pitch circle diameter, in									40·77	40·77	40·77	35·814	70·21
Net face width, in									17·2	17·2	17·2	8	10
Effective face width / Pitch circle diameter									2·34	2·34	2·34	0·98	0·75
Load/in of face width, lb	876	1,356	1,717 / 1,808	2,582	1,270	2,955	2,710	5,110	798	1,596	1,596	3,860	7,620
Maximum load/in of face width / Mean load/in of face width		3·0		1·4		2·1		1·5	4·2	1·6	1·0	1·1	1·1
Maximum load/in of face width, lb.		4,070		3,610		6,200		7,640	3,360	2,510	1,596	4,250	8,400
Load/in of face width, / Pitch circle diameter, lb/in/in	108·2 / 83·8	114	214 / 184	170·5	149·5	242	299	322	108·6	217	217	473	575
Maximum load/in of face width / Pitch circle diameter, lb/in/in		342		239		508		484	456	347	217	520	635
Scoring factor, P.V.T.	$0·68\times10^6$	$0·378\times10^6$	$3·9\times10^6$	$1·7\times10^6$	$0·69\times10^6$	$0·49\times10^6$	$2·76\times10^6$	$1·3\times10^6$	$0·368\times10^6$	$0·52\times10^6$	$0·52\times10^6$	$3·5\times10^6$ / $8·1\times10^6$	$3·8\times10^6$ / $4·05\times10^6$
Maximum P.V.T.		$0·655\times10^6$		$2·01\times10^6$		$0·71\times10^6$		$1·59\times10^6$	$0·755\times10^6$	$0·66\times10^6$	$0·52\times10^6$	$8·5\times10^6$	$4·25\times10^6$
Root stress, lb/sq in	7,345	8,060	10,000	11,800		11,400	9,000	11,750	5,300	10,600	10,600	30,400	19,500
Maximum root stress, lb/sq in		24,200		16,500		24,000		17,600	22,300	17,000	10,600	33,400	21,400

reduction of undulations to a degree permitting rapid removal of material by shaving and, or alternatively, lapping, and close control of helical angles; and safeguarding the gear meshing by adequate control of the boring and adjustment of gearcase housings and bearings.

In addition, the first design is based on either the use of the strongest material that can be hobbed and shaved accurately, and produced in the quantities required in an emergency, or the



——— Full load —— · —— Three-quarter load
— — — — Half load
Corrected over two-thirds of each helix

FIG. 3—*Load Distribution with Ends Shaved*

use of a slightly inferior but more readily available material necessitating correction of the helical angle of the pinion to provide even distribution of loading at high powers.

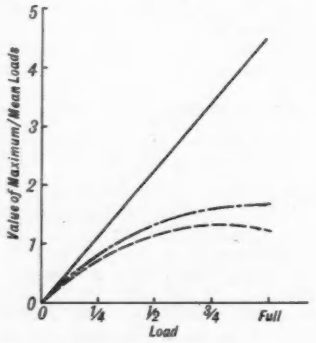
The following are details of materials accepted at present :—

Type of gear	Specification of material	Composition of material	Ultimate tensile strength, tons per sq in
Primary & main wheels	EN.30	0·3 per cent carbon, 4½ per cent nickel-chromium	60–65
Primary & secondary pinions	EN.26	0·4 per cent carbon, 2·5 per cent nickel-chromium - molybdenum	70–75

The loading chosen is based on experience with these materials and on the results of the United States National Boiler and Turbine Laboratory (N.B.T.L.) back-to-back tests (Monk, 1949).

With the second design the material of the pinions and wheel rims of the single helical gear sets will be similar to specification EN.36, but will have a low carbon content.

Both designs are required to fit the same shaft and turbine centres. No correction of the



——— No correction
— · — · — Corrected over two-thirds of each helix
— — — — Corrected over two-thirds with ends shaved in addition

FIG. 4—*Effect of Helix Correction on Load Concentration*

pinion for deflection is envisaged for the second design.

An analysis of details of design of some recently constructed gears is given in Table I.

Development Testing

A great deal of information on the aspects of design and production standards which control the load-carrying capacity of gearing can be gained from back-to-back testing on shore (Monk, 1949), and accordingly tests have been arranged of hobbed and shaved gears, to be carried out by the Marine Research Association ("Pametrade") using :—

(*a*) Spare gearing made for the steam gunboats ;

(*b*) Gearing of harder materials in the same gearcases ; and

(*c*) Gearing with pinions corrected to compensate for deflection under load.

Sets (*b*) and (*c*) will be produced by A.V.G.R.A.

Tests of case-hardened and ground gears are to be carried out by Pametrada using gears produced by A.V.G.R.A., representing a primary train of a double reduction set. Similar tests are to be carried out by Messrs. Vickers-Armstrongs, Barrow, using gears produced by A.V.G.R.A. and ground by the Maag Gearwheel Company, of Zürich, representing the secondary train. A second set of test gears has been made by Maag employing steel supplied by Poldi, which they are accustomed to using.

Correction of Pinion Helices to Compensate for Deflection Under Load and Small Misalignment Errors

The limitations on the length/diameter ratios of pinions caused by deflection are illustrated in Fig. 1. This diagram has been drawn for only one value of tooth stiffness and bearing size, but its general implications apply to pinions as a whole.

The idea of correcting the pinion helices was considered by Sir Charles Parsons forty years ago, but gears are only now beginning to be made of sufficient accuracy to permit the application and measurement of these corrections.

While correction for deflection and misalignment is common practice in the automobile and traction fields, its application to the marine field has been delayed not merely because of practical difficulties, but also because of a number of uncertainties. These were : the limits within which the position of the centre of the bearing reaction is known and hence, in part, the amount of deflection imposed ; the limits within which the value of tooth stiffness is known ; the effect of wear at partial loads ; the problems of meshing ; and the lack of actual practical experience.

An adequate estimate of the position of the centre of the bearing reaction can be made by assuming that the pressure carried by the oil film is inversely proportional to its thickness. Departures from parallelism of the journal and bearing axes shift the centre of pressure less than one-fifth of the bearing length.

An estimate of tooth stiffness can be made from available information (Davies and Semar, 1948, and Walker, 1946).

Wear at partial loads does not affect the correction given to traction and automobile gears of hard material. The use of a dummy pinion, with teeth made to the unloaded and uncorrected helix angle to be used against the wheel in the meshing frame and in the gearcase bearings, should enable satisfactory meshing and alignment to be maintained. The necessary tests are now being undertaken.

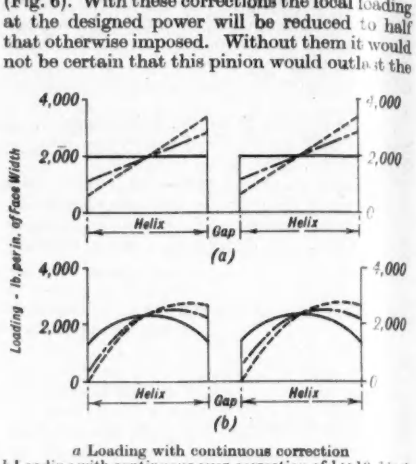
Correction of Double Helical Gears.—The simplest form of correction is to hob or grind the pinion to the helix angle which will give similar loading at each end of the helix under load. An improved form is to provide the unloaded helix angle on the inner thirds of each helix and to apply the corrected helix to the outer two-thirds only (Fig. 2).

Shaving back the outer quarter gives further improvement (as shown in Figs. 3 and 4) and safeguards against high end loading due to small errors in alignment.

It is hoped to apply this kind of correction to the gears of existing ships when the wheels are shaved. One of the sets to be tested by Pametrada will have a correction applied in this way ; the other will have a continuous correction over the whole face. This has been provided by using correcting cam control of the hob saddle nut as used in master screw-cutting lathes. A slight over-correction to safeguard against alignment errors can be provided with advantage (Fig. 5).

Correction of Ground Single Helical Gears.—The test pinions will be ground over half their faces to the nominal helix, and over the halves nearer the driving ends they will have an increased angle to compensate for deflection. This will provide approximately 20 per cent reduction in maximum loading at the designed power.

The loading pinion will be ground to the nominal helix over a third of the length only, and corrections will be applied to each end (Fig. 6). With these corrections the local loading at the designed power will be reduced to half that otherwise imposed. Without them it would not be certain that this pinion would outlast the



a Loading with continuous correction
b Loading with continuous over-correction of $\frac{1}{2} \times 10^{-3}$ inch at centre of each helix
——— No alignment error
— · — · — $\frac{1}{2} \times 10^{-3}$ inch alignment error
— — — — $\frac{1}{4} \times 10^{-3}$ inch alignment error

FIG. 5—*Pinion Loading Diagrams*

test pinions and hence be available for later testing of other sets.

Other Features

For second reduction gears an investigation was made into the amount of tip relief required to relieve the stress concentrations due to the "digging-in" effect at the roots of the mating teeth (Walker, 1946), the buttress effect of the adjacent unloaded tooth section (Davies and Semar, 1948), and the improvement of local lubrication conditions ; the tip relief required at 24,000 h.p. was estimated to be 0·002in.

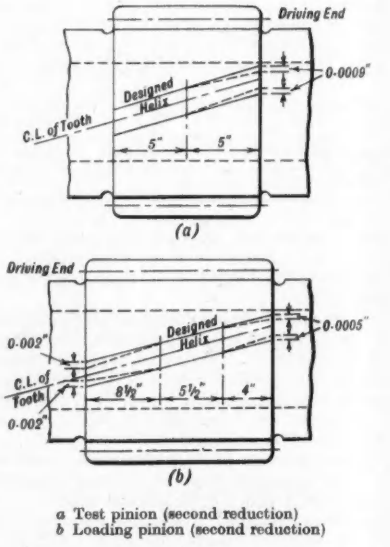
Provision has also been made for end relief (Tuplin, 1949) of 0·003in over a distance of $\frac{1}{8}$in for both the secondary and primary gear trains.

In both cases the roots of the teeth are to be polished in a direction perpendicular to the groove, to improve fatigue strength (Ulrich, 1942).

Further Tests

Two additional tests will be carried out in the second reduction series.

In one, both pinion and wheel will be made of



a Test pinion (second reduction)
b Loading pinion (second reduction)

FIG. 6—*Helix Correction on 12,000 H.P. Test Gear*

steel to specification EN.24 and skin hardened by induction heating, and, in the other, a case-hardened and ground pinion will drive an air-hardened hobbed and shaved wheel of ultimate tensile strength 60 tons to 65 tons per square inch.

The outcome of these tests will not be known

for some time, but the following implications of the two designs may be noted. Serving as an articulated design for two turbines at their present accepted loadings, they could transmit 5800 h.p. to a shaft running at 100 r.p.m., from turbines running at 2500 r.p.m. With the same diameters and face widths increased to give length/diameter ratios of 1·8 and 2·6 for the single and double helical gears respectively, and if the tests confirm that the corrections for deflection are fully effective, they could transmit 10,000 h.p.

The amount of additional power, which the tests confirm can be carried safely, will be of great interest.

Conclusion

While a great deal of work has been carried out in the last few years in improving marine gears, much remains to be done. As in other fields of engineering, the ideas which collectively provide the thread of development, and which have come to many different persons in various countries, have, in their translation into practice made demands on the techniques of various branches of engineering.

The future pace, certainty and effectiveness with which development will proceed will depend on the continuance and improvement of this co-operation.

Eastern Extension of the Pennsylvania Turnpike

The Eastern, or Philadelphia, extension of the Pennsylvania Turnpike has been opened to traffic. This famous American highway now virtually connects Philadelphia with Pittsburgh, via Harrisburg, and permits motorists to drive for a distance of 260 miles at a maximum speed of 70 m.p.h., without having to slow down for a single sharp curve, a level crossing or a traffic light. Along the 260 miles of turnpike there are seventeen restaurants and petrol stations and eighteen interchange road connections leading to Federal and State highways. There is a toll charge of 2·50 dollars, or about 1 cent per mile, and it is expected that approximately 3,000,000 vehicles will make use of the extended turnpike during its first year of operation. With no gradient more than 2 per cent and no curve of more than 4 deg, the new extension is a four-lane dual highway, similar to the original turnpike between Pittsburgh and Harrisburg. The dual roadways are each 24ft wide, separated by a 10ft strip of sod. On the outside of each roadway there is a 10ft wide shoulder of hard-packed waste deposits, and motorists can leave the concrete highway at full speed, if necessary, and pull over to the hard shoulders without fear of an accident. The project involved the construction of 193 bridges, three of them being structures of some magnitude. The extension was built in just over two years at a cost to the Turnpike Authority of 87,000,000 dollars.

Cartridge Turbo-Starters for Aeronautical Gas Turbines

THE starting torque required to raise the compressor speeds of gas turbines to the self-sustaining speed exceeds, by many times, the cranking torque for reciprocating engines of comparable horse power. Energy inputs of 50,000 ft-lb during starting cycles of only two or three seconds' duration have become common with larger units. Existing starter devices have either been electrically operated from 112V d.c. supply or have employed cartridge actuated pistons, but their torque and weight characteristics have indicated further development to be impracticable.

The use of cartridge turbo-starters is a natural result of the need to design a unit giving a high static torque with a low power/weight ratio as these are inherent properties of turbine units. Furthermore, the high starting torque can be more nearly sustained during a longer working cycle than is the case with the cartridge piston starter and the use of cartridges ensures that the aircraft is made independent of internal and external electric supplies, an important military consideration.

Present forms of turbo-starters now in production and in the final stages of development, employ a cordite charge burning at approximately constant pressure whilst the gases after expansion proceed at high Mach numbers to impulse-bladed turbines, which drive through reduction gearing to the output shaft. Much research has been directed to the solution of problems arising from the design of the nozzles, and the type of propellant. The first of these turbo-starter units to be fully approved by the Ministry of Supply and now coming into full production is that made by Rotax, Ltd., which we illustrate herewith (Figs. 1 and 2). This unit is fitted with two cartridge chambers connected to a common delivery duct leading to the nozzles. The wiring circuit ensures that if the screwed breech caps *E* are not properly secured the firing circuit cannot be completed. One cartridge usually suffices for each starting operation, the outlet port of the remaining chamber being sealed by a diaphragm which can only be perforated from the cartridge side. The charge is electrically detonated and burns approximately at a constant pressure of 60 lb per square inch throughout the working cycle of 3 seconds' duration. The gases then pass to the annulus *A*, through the ports *B* and are then expanded in four specially designed nozzles cut obliquely through the turbine backplate to suit the required inlet angle at the rotor. After passing through the impulse blading of the rotor the gases are discharged through the exhaust port, which has slight diffuser action. The backplate consists of two sections, the cut-off plate *C* being able to turn relative to the main section *D*; should the rotor exceed 40,000 r.p.m. a small angular displacement of the cut-off plate is effected automatically, thereby closing the nozzle ports. A bursting disc fitted on the inlet side becomes effective in the event of nozzle blockage

The 5in diameter rotor is machined from a solid forging of creep-resistant ferritic steel and is fitted with thirty-two blades having equal inlet and outlet angles and subtending 134 deg. The whole rotor assembly is dynamically balanced at 60,000 r.p.m. The maximum

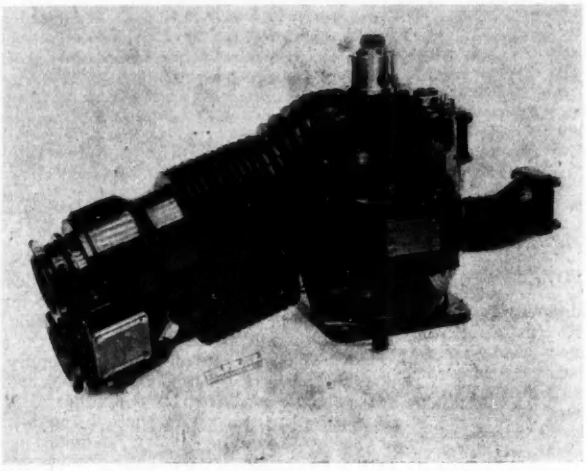


Fig. 1—Rotax Cartridge Turbo-Starter

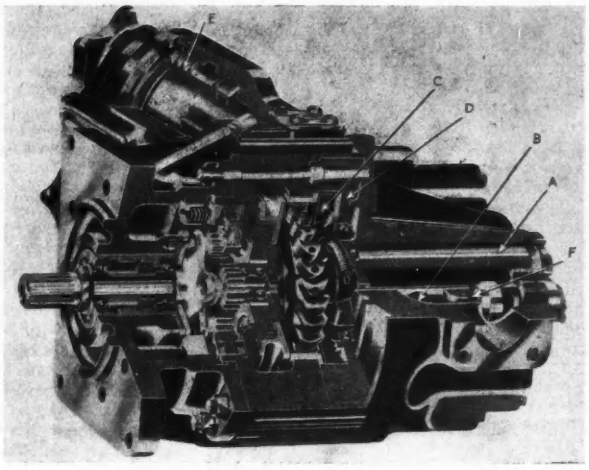


Fig. 2—Cut-Away View of Rotax Starter

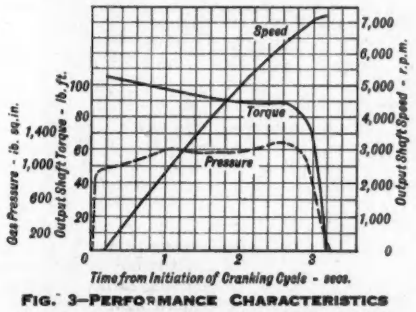


Fig. 3—Performance Characteristics using Charge Woolwich CSC. 720GR

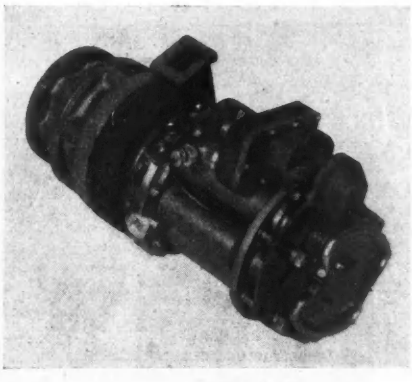


Fig. 4—Plessey Cartridge Turbo-Starter

working speed of the rotor is 40,000 r.p.m., which is taken through a single-stage 5 : 1 epicyclic reduction gear to the output shaft. The sun gear is splined on the rotor shaft, which runs in an angular-contact double ball race and is able to absorb the small axial thrust. Attached to the annulus gear is a spring-loaded multi-plate torque limiting clutch, which is set to allow the annulus to slip at torques in excess of 180 pounds-feet. The cap cartridges, which are fired simultaneously, the gases from each leading to a nozzle on opposite sides of the rotor. The three-shot breech is automatically indexing. The rotors drive through a double combining and speed-reducing gearbox, to a torque limiting clutch, the system being diagrammatically illustrated in Fig. 5.

Initially the turbine accelerates at no-load until a dog-engaging mechanism actuated by

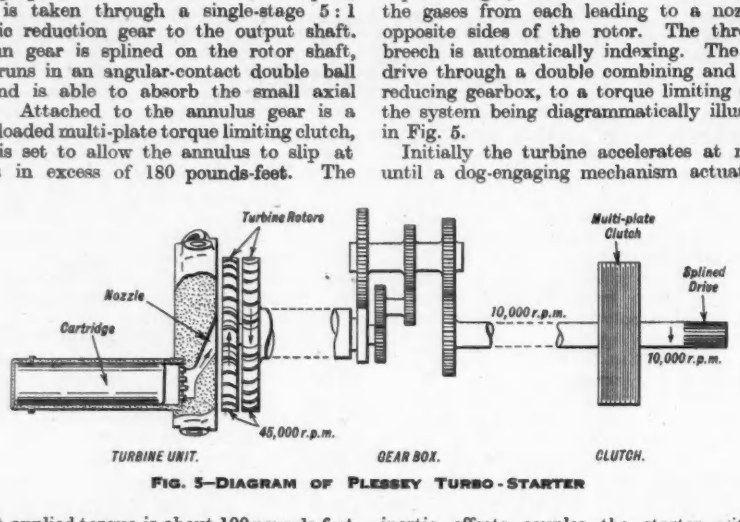


FIG. 5—DIAGRAM OF PLESSEY TURBO-STARTER

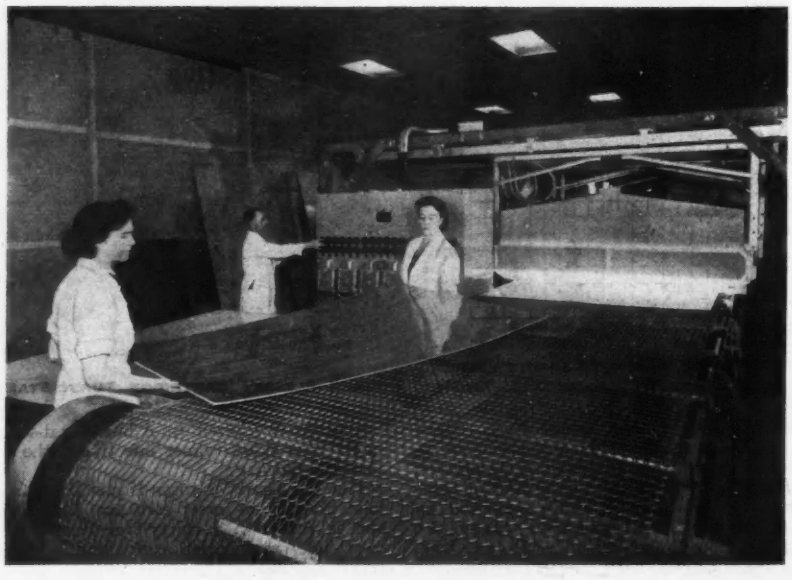
greatest applied torque is about 100 pounds-feet at which the annulus is anchored and the planet carrier rotates with the output shaft. A further stage of reduction gearing is carried in the engine installation. Characteristic performance curves are shown in Fig. 3 for an ideal starting sequence. In this case the aircraft turbine, which is fired simultaneously with the cartridge, begins to supplement the torque provided by the starter and thus accounts for the flattening out of the torque curve towards the end of the cycle. The horsepower developed at the maximum speed of 45,000 r.p.m., is 155 h.p. Adequate cooling during the short working period is provided by the use of ribs embodied in the cartridge chamber and the body assembly. Lubrication is provided by the parent unit through the connecting flanges. The details of the shaft couplings are in accordance with S.B.A.C. standards. The body and housings are of aluminium alloy and the whole unit weighs 60 lb.

Another cartridge turbo-starter shown in Fig. 4 is that made by the Plessey Company, Ltd. It is now undergoing final development trials, for which purpose it has been fitted in a Napier "Naiad" engine. This unit is believed to operate under high temperatures and extremely great velocities and employs a pair of contra-rotating impulse-bladed rotors, thereby dispensing with stator blading. This system was adopted to reduce the weight and working temperatures of the rotors whilst allowing a maximum relative blade velocity. The charge is contained in two percussion inertia effects couples the starter with the engine, which is then accelerated to self-sustaining speed, the whole operation occupying a period of approximately two seconds. The torque-limiting clutch absorbs the relatively small amount of energy in the system at the moment of engagement of the starter shaft with the load early in the working period. The output shaft speed rises to 9000 r.p.m., at which speed the starter is delivering approximately 125 h.p.

Infra-Red Heating for a Wood Finishing Process

AN infra-red heating equipment has been developed by the General Electric Company, Ltd., for the stoving of a new hard-wearing, fire-resistant wood finish introduced for interior decoration purposes by Saro Laminated Wood Products, Ltd., of the Isle of Wight. This finish consists of a liquid plastic which, when sprayed on to a timber surface and dried under radiant heat lamps, hardens and leaves a fire-resisting, resilient, plastic coating. The coating can be either transparent or pigmented and panelling made by the process combines the advantages of plastics with the natural beauty of decorative veneers.

With this stoving process the resin coating applied to panels is fully polymerised and made hard but flexible. The plant, which is illustrated below, has been designed to treat panels up to 8ft long and 5ft wide.



INFRA-RED STOVING UNIT

In the stoving unit 216 Osram industrial infra-red reflector lamps are mounted horizontally over a conveyor belt which carries the panels through the heating zone. The lamps are arranged in three self-contained sections to form a heating bank 15ft long by 6ft wide, and they are suitably spaced with sheet metal of high reflectivity. Side and end reflectors designed to complete an unbroken reflective surface prevent the loss of stray radiation and maintain a high overall efficiency.

A rigid framework of angle iron supports each section in the heating bank, and each of the sections, together with its lamps, can be easily withdrawn for cleaning and maintenance purposes. The complete framework is suspended on roller bearings from overhead girders and provision is made for varying the spacing between the lamps and the conveyor belt from 12in to 20in to suit the class of work in hand.

The woven wire conveyor belt, which is 52ft long and 5ft wide, is driven by a squirrel-cage motor and its speed is infinitely variable between 2ft and 6ft per minute. The equipment is wired for balanced connection to a three-phase supply, and is rated at 54kW. The switchgear at the side of the stoving unit is arranged to permit each row of lamps, each section, or each half-section to be switched independently. This switching arrangement makes possible a wide variation in heat intensity and the plant can be used to stove finishes of different compositions on wood of different kinds and with varying moisture contents or other characteristics.

Engineering Research in South Africa

THE fourth annual report of the South African Council for Scientific and Industrial Research contains several references to important research activities of interest to engineers.

Since the advent of import control the suitability of South African clays for foundry use has become a critical problem, and investigations about the constitution of a number of South African clays, especially those being used to replace bentonite in foundry sands, are in progress. The report states that no South African clay containing a large proportion of minerals of the montmorillonite type has yet been found. Clays being used with some success are illites, which do not seem to be uncommon. Attention is also being paid by the National Chemical Research Laboratory to a group of plastic clays used in the Transvaal, which consist of kaolinite, but have very high base exchange capacities.

A problem of fundamental significance which is being studied by C.S.I.R. is the corrosion of iron. Up-to-date apparatus was acquired last year, and a number of practical corrosion problems, both from outside bodies and from the National Chemical Laboratory itself, have been dealt with.

The production of chromium by the electrolysis of chromous salt prepared from low-grade Transvaal chromite is also being investigated. Preliminary work has progressed far enough for the design of a small pilot plant to be undertaken. A new method of measuring preferred orientation in metals and alloys has been developed by the National Physical Laboratory, and a prototype model of the necessary apparatus has been built and successfully tried out.

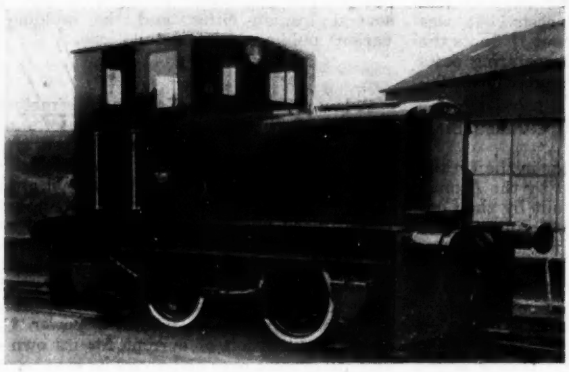
The radiation division of the laboratory has also designed and built a high-temperature camera. This unit will enable X-ray studies to be made of phase changes up to 1500 deg. Cent., which will be particularly useful in work on metals and alloys.

During the year under review the Johannesburg industrial research team of the National Institute of Personnel Research carried out an increased amount of testing on a number of projects, such as the selection of artisan apprentices. In addition, the team tested all pupils at the Johannesburg Trades School to obtain additional material for the validity and standardisation of artisan selection tests and assisted in the selection of administrative trainees and other work for the Iron and Steel Industrial Corporation, Pretoria.

A Diesel Shunting Locomotive

A RECENT addition to the range of "Planet" industrial locomotives made by F. C. Hibberd and Co., Ltd., Park Royal, London, N.W.10, is the 18-ton diesel shunting engine illustrated on this page.

This locomotive has a Dorman "4DL" Mark III engine, of 120mm bore by 180mm stroke, which develops 77·5 b.h.p. at 1200 r.p.m. The engine is suspended at three points on anti-vibration mountings in the heavy steel section fabricated frame of the locomotive. Power is transmitted through a fluid coupling situated in a bell housing at the rear of the engine. Drive is taken by a propeller shaft to a Wilson air-operated four-speed gear unit at the forward end of a bevel reverse and final reduction gearbox. The final drive from the gearbox to the rear axle is by a heavy triplex roller chain and the axles are coupled by duplex chain.



18-TON DIESEL SHUNTING LOCOMOTIVE

In low gear the tractive effort of the locomotive is 7480 lb, in second gear 4430 lb, in third gear 2940 lb, and in top gear 1830 lb. The maximum speeds in these gears are 3, 5, 7½ and 12 m.p.h. respectively.

The axles on which the 3ft 1½in diameter rolled steel wheels of the locomotive are mounted are carried in cast steel split axleboxes, the top halves of which carry well-proportioned bearings oiler pad lubricated from oil sumps in the lower halves. Laminated springs, fixed to the upper half of each axlebox, slide in renewable pads in spring guides. Each axlebox is connected to the frame by radius rods which, in addition to compensating for chain length variation with the rise and fall of the wheels, provide means for chain tensioning.

Brakes on all four wheels of the locomotive are actuated by Westinghouse compressed air equipment interconnected with hand screw parking brake control. Four-box sanding, operated by compressed air, is provided for the leading wheels in each direction of travel. The buffers and drawgear comply with British railway requirements and consist of 16in self-contained spring buffers and central hook with three-link coupling. Electric lighting is provided for both directions of travel and the cab light is also electric. Power for lighting and engine starting purposes is supplied by dynamo-charged heavy-duty 24V batteries.

In designing the new locomotive particular attention was paid to giving the maximum possible accessibility to all parts for maintenance and inspection purposes, and many of the major units can be removed without disturbing other components. The particularly spacious driver's cab is provided with large look-out windows, and the duplicated controls on each side of the cab coupled with the air operation of gears greatly facilitates work when shunting. The locomotives are made for 4ft. 8½in. and 5ft 6in gauge systems, and in each case are 18ft 2in long overall, 10ft 8in high and have a wheel base of 5ft 6in.

American Engineering News

Raising a Sunken Dredger in New York Harbour

In one of the more unusual lifts ever attempted in New York harbour, a salvage team of the Merritt-Chapman and Scott Corporation working for the U.S. Army Corps of Engineers, recently raised a 150-ton bow section of the dredger "Sandcraft," which was sunk on July 2, 1950, after colliding with the collier "Melrose" in the Narrows between Brooklyn and Staten Island. After having been cut loose from the rest of the hull by underwater demolition charges placed by divers, the large wedge of bow section was raised by means of the floating derrick "Monarch," whose lifting capacity of 225 tons makes her the most powerful commercial floating derrick in the United States. The section measured approximately 30ft in length, 31ft in height from keel to forecastle head and 43ft across at the widest point of the beam. It was rigged by means of two sets of slings, one running through the hawse pipes of the sunken vessel, the other one through holes cut in the bow just above its forefoot, aft of the stem. The remainder of the 261ft hull of the "Sandcraft" is being broken up progressively under water and will be raised in heavy sections until the entire structure is removed. Prior to the start of the heavy demolition work divers using underwater cutting torches had freed all of the machinery and mechanical equipment of the vessel to facilitate the task of raising it to the surface by a derrick. An interesting aspect of this project was the requirement to remove the oil remaining in the fuel tanks of the "Sandcraft," so as to avoid pollution of the waters of New York harbour. In order to accomplish this, a cofferdam, 23ft by 22ft in area and 26ft in height, was constructed of timber and reinforcing steel and lowered over the boat deck of the sunken vessel. Until this cofferdam provided protection against the strong currents in the Narrows divers had been able to work on the "Sandcraft" only during the brief periods of slack tide each day. However, once the cofferdam was in position the divers cut through the boat deck, the shelter deck and the main deck, establishing a clear entry to the vessel's engine-room. They were then able to manipulate the engine-room valves and to attach the suction lines through which the fuel oil was pumped to barges at the surface.

Shipbuilding Activities in the Great Lakes Region

Shipyards situated on the Great Lakes are experiencing their busiest season since the end of the war, orders to the extent of approximately 40,000,000 dollars having been placed. Following the completion of the S.S. "Wilfred Sykes," the largest bulk cargo carrier ever to be built or operated on the Great Lakes, a considerable number of ore boats have been ordered by the ore-carrying subsidiaries of several American steel companies. The "Wilfred Sykes," which was built by the American Shipbuilding Company, of Cleveland, Ohio, for the Inland Steel Company, of Chicago, has a length of 678ft and a total fresh water displacement of 28,510 tons. The larger vessels now under construction include three ore carriers for the Pittsburgh Steamship Company, with a length of 647ft and a cargo capacity of 18,000 gross tons; a limestone-carrying boat for the Bradley Transportation Company, which will be 666ft long and will have a capacity of 20,000 gross tons; an ore vessel for the Interlake Steamship Company, 647ft long and with an 18,000-ton ore capacity, and another ore vessel for the Cleveland-Cliffs Steamship Company, also 647ft long, and with an approximate cargo capacity of 19,000 gross tons. In addition, several automobile ferryboats are under construction at Great Lakes yards, and a number of contracts have been placed for the conversion and repowering of some of the older vessels with a view to increasing the capacity of the Great Lakes fleet. Thus, at present, two of the larger vessels of the Cleveland-Cliffs Steamship Company are being converted from coal-burning reciprocating steam engines to oil-burning steam turbine machinery of 3000 s.h.p. each. An interesting consequence of the building of the large bulk cargo carriers is the need for the U.S. Corps of Engineers to deepen certain connecting channels and harbours before these new ships can be loaded to full capacity.

A New Synthetic Fibre

A synthetic fibre, which is likely to be of considerable interest to industry, has been announced by E. I. du Pont de Nemours and Co., Inc., who developed and introduced nylon in this country. The new "Orlon" fibre is a polyacrylonitrile, and, as such, it is of the same family as the acrylonitrile synthetic rubbers. The control of its properties is effected, in the first instance, by controlling the molecular weight, or length of chain, during polymerisation. Acrylonitrile polymers of the lower molecular weights possess the flexibility and ability to stretch which is found in the synthetic rubbers of the "Buna N" kind. The molecular weight of the new material for textile fibres is sufficiently higher to give the synthetic fibre greater rigidity. "Orlon" is stated to possess good dielectric properties, especially at micro-wave frequencies. It is combustible, but does not flash into flame. It has excellent water resistance, absorbing only 2·5 per cent, as compared with 8 per cent for nylon and 60 per cent for acetates. The material is said to retain reasonable strength when heated and should be suitable for use at a temperature somewhat above the boiling point of water. Its alkali resistance is poor, but it is able to withstand attack by mineral acids, the common solvents and oils and greases. Industrial applications which are envisaged for "Orlon" include filter fabrics, electrical insulation, conveyor belting, anode bags and sewing threads.

A Large Plastics Moulding Machine

A 200oz capacity injection moulding machine, which has been installed by the A. L. Hyde Plastics Company, of Grenloch, New Jersey, is claimed to be the largest machine of its kind in the world. The press is electrically operated and has a 50 h.p. main motor and a 10 h.p. auxiliary motor for clamping and holding operations. An interesting innovation is that the machine has a separate pre-plasticising cylinder, which speeds up the operation of the press, as the main injection cylinder is loaded automatically by the pre-plasticising cylinder while the product is curing. Upon removal of the moulding, the main cylinder is ready immediately to reload the dies with pre-plasticised material. Electric resistance units with a total load of 29kW are built into the press cylinders, and, with the aid of automatic controls, keep the plastic material at the appropriate temperatures. Reduced voltage starters and a capacitor unit allow the machine to be electrically loaded at unity power factor.

Power Generation at Anderson Ranch Dam

The latest hydro-electric power plant in the North-West of the United States began generation on November 20th, when the Bureau of Reclamation put the first of three 135MW generators at Anderson Ranch Dam in Southern Idaho on to the line. The initiation of service at this installation within the Boise Project brought the total number of plants operated, or under construction, by the Bureau of Reclamation in the West to twenty-eight. The new power plant will be operated in co-ordination with existing Federal plants of the Boise and the Mimidoka projects in order to obtain a

greater output of firm power from these installations. Anderson Ranch Dam is believed to be the highest earthfill dam in the world. Its crest is 456ft above bedrock; it is 2650ft wide at the base, 1350ft long at the crest and contains 9,653,300 cubic yards of earth and rock. Its reservoir has a storage capacity of 493,200 acre-feet. Construction of the dam was begun in August, 1941. Due to wartime conditions, the embankment was not finished until 1949.

Precision Casting with Frozen Mercury

The Metallurgical Products Division of Thompson Products, Inc., of Cleveland, Ohio, has started using an interesting precision casting process in the manufacture of complex turbine parts. Known as "Mercast," and patented by the Mercast Corporation of New York, the new process is probably the latest variation of the lost-wax precision casting method. With the help of improved ceramic investment materials and a new dipping technique, the process has made possible the casting of intricate shapes involving thin sections and sharp edges and having a high degree of surface finish as well as great dimensional accuracy. The following procedure is employed by the company:—A metal die, made to the precise contours of the finished part, is filled with mercury and then submerged in an acetone bath maintained at a temperature of —135 deg. Fah. The mercury freezes, leaving a solid mercury part, which is an exact replica of the eventual component. The frozen part is lifted out of the die with the aid of dental type instruments and is attached to a frozen mercury sprue. Only slight pressure is required to "touch-weld" the adjoining surfaces of frozen mercury, and several of the solid mercury components are attached to a single sprue, building up a so-called Christmas tree pattern. The latter is then dipped in a series of ceramic slurries in order to build up a coating approximately $\frac{1}{4}$in thick. This thickness compares favourably with that required in the process of wax precision casting. Between eight and twelve dips in cold non-aqueous ceramic slurries are necessary to build up the coating which hardens as the solution evaporates. On account of the relatively thin and permeable ceramic it is possible for any casting gases to escape. Once the coating is hard, the mercury is melted out by spraying mercury at room temperature against the frozen mercury of the pattern. Thus controlled melting conditions are obtained and blocking of mould passages is prevented. Furthermore, sudden expansion of the frozen mercury, which might lead to mould cracking, is avoided. The melted-out mercury is recovered and used again. After firing for about three hours at 1850 deg. Fah. the mould becomes ready for the actual casting of metal. The metal is melted in induction furnaces and about seventy castings, each consisting of a number of patterns, are poured from each heat. A large variety of metals, ranging from aluminium to alloy steels, have been cast successfully with the aid of the mercury process. Dimensional tolerances of $\pm 0{\cdot}002$in to $\pm 0{\cdot}005$in have been maintained in the finished components. Equipment is now available for facilitating the production of stainless steel castings weighing as much as 20 lb each. The process is being applied to the production of hollow turbine blades, which have two internal ribs running along the full length of the blade. The company states that the frozen mercury process has made possible a high rate of production, a very low rate of scrap loss and the elimination, to a large extent, of machining operations.

Shipbuilding in the United States

Speaking at the fifty-eighth annual meeting of the Society of Naval Architects and Marine Engineers in New York, Mr. John B. Woodward, jun., the President of the Society, mentioned the discouraging outlook at present facing the American merchant navy and the shipbuilding and repair industries. Due to the Korean war there has been a certain amount of repair and reconditioning work, which helped to end the slackest period since the war. However, this was not sufficient to bring the industry back to its level of activity of a year ago. For example, there had been no new ship construction on the Pacific Coast since the launching of the liner "President Wilson" in June, 1948. Employment in the San Francisco shipyards was down to 1500 last spring, the lowest in nearly twenty years. The situation was somewhat better on the East Coast, mainly due to materials, labour and planning costs being lower than in the West. With regard to future shipbuilding activities in the U.S., the Federal Maritime Board proposed to build 200 cargo vessels having a speed of 22 knots to 24 knots and a displacement of 12,500 tons. The Moore-McCormack Lines, Inc., had plans for the construction of two 23,000-ton luxury liners with a speed of 23 knots, to be introduced into the service between New York and the East Coast ports of South America. In tanker construction consideration was being given by the major American oil companies to the design and construction of a new class of "super-tankers." Deadweight capacities of 40,000 tons and overall lengths of 750ft had been used as a basis of preliminary schemes, and the vessels were intended primarily for the long-haul routes to the Near East, where large cargoes would reduce transportation costs. It was believed that with speeds of about 18 knots the projected tankers would have operating costs approximately the same as the present 28,000-ton carriers.

Nuclear Reactor at North Carolina State College

The first nuclear reactor in the United States not owned and operated by the Atomic Energy Commission is to be built by the Consolidated University of North Carolina. The proposed reactor, which will provide facilities for nuclear engineering research and education, will be situated at Raleigh, North Carolina. It will be of the uranium "water boiler" type, similar to a reactor which has been in operation at the Los Alamos Scientific Laboratory of the Atomic Energy Commission for several years. The nuclear fuel is uranium in the form of a uranyl salt dissolved in water. The solution will be contained in a small stainless steel cylinder. Enriched uranium, containing not over 1kg of the fissile uranium 235 isotope, and several gallons of water will be used. Cooling coils, sampling lines, thermocouples, control rods of boron and cadmium and other auxiliary equipment will be attached to, or embedded in, the fuel cylinder. The entire apparatus will be enclosed in 4ft to 6ft of concrete, and operation will be controlled from a remote console. The reactor is designed to operate at a maximum power output of 100kW, though routine operation will probably be at a lower level. However, even if the reactor should operate at the maximum level continuously, less than 3 grammes of the uranium fuel would be used up each year.

Propellers for High-Speed Aircraft

A series of propellers for aircraft flying up to 1000 m.p.h. has been developed by the Curtiss-Wright Corporation, of Caldwell, New Jersey. The propellers will be used initially to equip bombers, troop-carrying aeroplanes and transport aircraft currently capable of cruising at speeds from 500 to 600 m.p.h. They are particularly intended for use in conjunction with turbine engines within a 2500 h.p. to 20,000 h.p. range. They may be feathered in the event of engine failure and may be reversed to act as brakes on landing. The propellers are being manufactured as the "turbo-electric" series and are, at present, being tested by the Air Matériel Command of the U.S. Air Force at Wright-Patterson Field. Among the first military applications will be their use on the turbo-prop version of the long-range Douglas C-124 troop and cargo-carrying transport. The turbo-electric series includes both single and dual contra-rotating propellers with varying numbers of blades. Single-rotation subsonic and transsonic propellers are made in three or four-bladed models. The dual contra-rotating models have six or eight blades arranged in two banks of three or four each. The blades are of steel construction, are approximately rectangular in shape and have square tips. The manufacturers claim that the new propellers will enable the full potentialities of gas turbine engines to be realised.

French Engineering News

(From our French Correspondent)

The launching of the 602-ton vessel "Brest," will result in the cross-channel ship, "Bordeaux," being taken off the Newhaven-Dieppe line after thirty-eight years' service. The "Brest" will enter service next spring. The passenger ships "Londres" and "Aromanches," will be joined in 1952 by the "Lisieux." For the Calais-Dover and Folkestone-Boulogne services two new keels have been laid down: the "Côte d'Azur," 3500 tons, and the "St. Germain," a ferry, 3000 tons. These two ships will come into service next spring.

* * *

The Société d'Etudes et Travaux pour le Moyen Orient, which includes the Pont-a-Mousson foundries, the Sté. d'Eau et Assainissement, the Ets. Billiard and the Sté. Etudes et Entreprises, has received a contract from Iran for the construction of dams and barrages, a complete water distribution system in several Iranian cities, and the building of various public service installations.

* * *

A law passed by the National Assembly last year, which permits the construction of electric power plants outside the nationalised group, is now being studied by various undertakings considering the building of private electricity generating stations. Under this law, no generating plant under 8000kVA comes under the Electricité de France, nor do new installations over and above that power provided they are not for public service and agreement is reached with the electricity authority. Any industrial undertaking can now install a power plant for the generation of current for its own use and sell current over and above its own requirements to Electricité de France.

The Electricité de France has to agree to the construction of such generating plants and proposed plants, which must be accepted before construction, must in no way interfere with the electricity plan laid down for Electricité de France. It is also stipulated that orders given for material necessary to the construction of the generating plants must not interfere with orders given by Electricité de France for material for nationalised expansion plans.

* * *

In an effort to save French shipyards, which are suffering severely from competition owing to the high French prices, the government is studying a long-term plan to help the industry. Meanwhile short term aid is being given and some £6,000,000 is being devoted to the modernisation of shipyard plant and equipment. Shipbuilders are being granted loans at reduced interest, payable in twenty years, and the amounts lent are based on the type of ships to be built. Such loans consist, for example, of 70 per cent of the cost of a liner, 72·5 per cent of the cost of a refrigerated ship, 80 per cent for cargo vessels and tankers. It is expected that about 60,000 tons will be built from loans amounting to a total of almost £5,000,000.

* * *

The County Councils of the Northern *departements* of France have voted in favour of reconstructing a number of canals to improve transport in the area. The decision will now be placed before the government, which will be asked to make the funds immediately available in order that the work can start as soon as possible. The plan calls for the widening and deepening of canals between Dunkirk and Lille, Lille and Roubaix, and in the whole Paris region, to permit the passage of boats and barges with a displacement of from 1350 tons to 1500 tons.

Other projected works would bring industrial centres not at present served by canals into the network as well as linking Lille with the Escaut and so bringing Belgium into the circuit.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour has reported that the total working population of Great Britain at the end of October was 23,500,000, a figure which indicated an increase of 46,000 (14,000 men and 32,000 women) during the month. That total included 723,000 who were serving in H.M. Forces. At the end of October there were 22,473,000 (15,235,000 men and 7,238,000 women) in civil employment, an increase of 25,000 compared with the end of September.

During October, there was a further decline in the number of people employed in the basic industries of the country, the biggest drop, 9000, occurring in transport and communication, and in the coalmining industry the number of wage earners fell from 690,000 to 687,000. In the manufacturing industries, however, the number of people employed increased from 8,500,000 to 8,543,000. In this classification there was a significant increase of 22,000 in the manpower of the metals, engineering and vehicles trades, the end of October total being 3,999,000, compared with 3,922,000 at the end of last year.

Figures for unemployment, issued at the end of last week by the Ministry of Labour, show that on November 13th there were 302,071 people registered as out of work, compared with 304,063 on October 16th. The November total included 195,478 men of eighteen and over, of whom 3258 were reported to be temporarily stopped. The unemployment figure, the Ministry says, represented about 1·4 per cent of the total number of employees insured under the National Insurance schemes.

Iron and Steel Production

British steel production in November reached the highest rate yet achieved, the average weekly output of 336,000 tons of ingots and castings representing an annual rate of 17,472,000 tons. In November of last year production was at an annual rate of 16,358,000 tons. Production of pig iron during November averaged 193,100 tons weekly or an annual production rate of 10,042,000 tons.

In publishing these figures, the British Iron and Steel Federation says that orders for steel for the home market fell in the first part of this year, but have increased sharply in recent months. But so far, it appears, there is little evidence of expanded programmes for defence making a large demand on steel supplies except in the case of a few products. The Federation states that steps are being taken to limit the steel industry's export and that, it is claimed, together with the high level of steel production, should enable supplies for the home market to be appreciably increased. Expansion in sheet supplies, it is added, will follow the coming into operation of the new plant at Margam in the middle of next year. The Federation points out, however, that maintenance of steel production at a high level can be greatly assisted if all steel-using firms will return their scrap as rapidly as possible, whether it arises from current operations or from the scrapping of obsolete plant and buildings.

Productivity in the Steel Industry

Speaking at the annual meeting of Dorman, Long and Co., Ltd., on Thursday of last week, Sir Ellis Hunter, the chairman, said that striving after the highest possible productivity had been the British steel industry's consistent policy since 1945. In that endeavour, the whole industry had participated and no section had failed to make the necessary effort. More than three years ago, Sir Ellis recalled, the men agreed to the introduction of the continuous working week in the melting shops, when in many other important industries there had been pressure for the introduction of the five-day week.

In 1945, Sir Ellis continued, managements produced their co-ordinated plan of national development and, what was more, put it into operation in a way in which it had made good progress ever since. They had also used to the utmost the resources of their own organisations and of the industry's organisation to secure adequate supplies of raw materials and a free flow of the industry's products to the consuming trades. In all this work, Sir Ellis pointed out, there had been no need to urge either men or managements. Repeated exhortations to produce more, which had been showered upon industry generally, were not required for the iron and steel industry, where the need had been recognised long before it was acknowledged elsewhere. The advent of the dollar crisis with the imperative call for exports and, more recently, the rearmament programme, proved how right the iron and steel industry had been in the policy it had pursued throughout the post-war period. All employed in the industry, whatever their status, were entitled to full credit for the record of unstinted effort.

Sir Ellis went on to say that the production record of the iron and steel industry in recent years was a reflection of its endeavour to do its utmost to give the nation what it needed and, in the present circumstances, the Government might have been expected to hold its hand and allow the industry to continue with its efforts undisturbed by political action. The problem of the relationship between the steel industry and the State had been shown to be capable of permanent settlement on a basis that involved the fullest protection for the public interests. It had been hoped that the relations between the industry and the state would be placed on an effective and permanent basis, but the discussions had been suddenly terminated without any reason being given beyond the bald statement that the Cabinet had decided to proceed with nationalisation. But, Sir Ellis observed, there need be no speculation regarding the attitude of the leaders of the steel industry because they had declined in the present political situation to nominate members to serve on the Corporation, which had been set up. The answer was simple and could be stated categorically. The leaders of the steel industry would continue to conduct their affairs with only one purpose in view, which was the continued development of the industry for the highest public service, endeavouring to raise productivity and increase efficiency so that its products were available in the largest possible quantity at the lowest possible price.

Imported Copper Supplies

The Ministry of Supply has announced that from January 1, 1951, until further notice, supplies of imported virgin copper to consumers will be restricted to a total each month equal to their average monthly consumption in the first half of 1950. Individual quotas will be notified to consumers by the Directorate of Non-Ferrous Metals, Rugby. The quota for each consumer will be based on the returns of consumption of imported virgin copper made to the Bureau of Non-Ferrous Metal Statistics. No further delivery contracts will be made until the quotas have been notified.

Consumers of imported electrolytic copper in special shapes and to special specification, for instance vertically cast wire bars or 1000 lb vertically cast cakes, will be restricted to a monthly quota of two-thirds of their average monthly consumption of those shapes in the first half of 1950. The short delivery of one-third of special shapes may be made up, if the consumer so desires, by deliveries of standard shapes, subject to the overall limitation on supplies notified above.

The Ministry will accept orders for delivery subsequent to the month of order, only for a tonnage which does not exceed two-thirds of the quota notified.

Wage Claims,

At a meeting last week, between representatives of the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions, agreement was reached on wage increases for workers in the shipbuilding and ship-repairing industry. By the new agreement, existing rates and bonus payments for timeworkers are consolidated in a uniform rate of £6 a week for skilled men over twenty-one and £5 a week for unskilled men. This represents increases of eleven shillings a week for skilled and eight shillings a week for unskilled men. The rates, it should be added, apply for the normal working week of forty-four hours. The Employers' Federation has undertaken also to review piece-work prices and bonus schemes where the final weekly payments above the new national time rates are less than 17s. 6d. to skilled workers and 15s. to semi-skilled or unskilled workers. Appropriate adjustments are to be made in the wages of apprentices and youths, and all the increases are retrospective to the first pay week after November 15th.

No settlement has yet been reached over the wage claims advanced by the three railway unions. The claims were for increases of 10 per cent, made by the National Union of Railwaymen, 15 per cent, made by the Associated Society of Locomotive Engineers, and Firemen, and 7½ per cent made by the Railway Clerks' Association. The claims were refused by the Railway Executive, but a fortnight or so ago the Executive made an offer of wage increases provided the unions would agree to certain measures to increase efficiency and promote economy on the railways. That conditional offer was rejected by the three unions, which subsequently made a joint approach to the Minister of Labour on the matter. After meetings on Wednesday and Thursday of last week with the Railway Executive and with representatives of the unions, the Minister announced his intention to set up a court of inquiry to investigate the rejected wage claims and to make recommendations. It is understood, however, that the court's recommendations will not be binding on the parties.

Coalmining Manpower

The report has now been published of the Manpower Committee set up in November by the National Consultative Council for the Coal Industry. The committee's terms of reference were "to consider the present manpower situation in the coalmining industry, to recommend the means by which wastage might be arrested and recruitment improved, and to suggest how the constituent bodies of the Council might jointly or severally contribute to an improvement of the situation."

During its investigation the committee found that, in the first forty-four weeks of 1950, manpower fell by 22,400, compared with a fall of 17,700 in the corresponding period of last year. Recruitment totalled 46,000, which was about 1000 more than in 1949. In its report the committee has stated that the wastage this year has not been caused by an increase in deaths, retirements, sickness and dismissals, but mainly by other causes such as the lifting of the Control of Engagement Order, dislike of the nature of the work, dissatisfaction with promotion prospects, housing difficulties and other personal reasons.

The committee has made some recommendations as to measures which might be adopted to reduce manpower wastage in the coalmining industry. Among them it has stressed in its report the way in which recruits are received and looked after during their first few months in the industry. It claims that much depends on the skill and sympathy with which training officers fulfil their tasks and their success, the committee suggests, should be kept under review.

Personal and Business

SIR ARCHIBALD FORBES has been elected deputy-president of the Federation of British Industries.

LIEUT.-COLONEL AUSTIN G. BATES, D.S.O., has been appointed a director of the Cunard Steam Ship Company, Ltd., and of Cunard White Star, Ltd.

BRAITHWAITE AND CO. ENGINEERS, Ltd., states that its address is now Dorland House, 14–16, Regent Street, London, S.W.1 (telephone, Whitehall 3993).

GEORGE SALTER AND CO., Ltd., West Bromwich, announces the appointment of Mr. R. L. Eccleston as publicity manager in succession to Mr. A. Willington.

MR. N. MEDRINGTON, A.M.I.C.E., A.M.I.W.E., chief engineer to the Lee Conservancy Catchment Board, has been appointed chief engineer to the Avon and Dorset River Board.

MR. P. C. SHARP and Mr. D. S. A. E. Jessop, directors of the Brush Electrical Engineering Company, Ltd., have been appointed to the board of Brush Coachwork, Ltd., Loughborough.

THE MACHINE TOOL TRADES ASSOCIATION announces that Mr. W. J. Morgan, M.I.Mech.E., has been appointed general manager, and Mr. H. W. Flinn, secretary, as from January 1, 1951.

MR. WILLIAM PORTON has relinquished his appointment as assistant cost accountant at General Refractories, Ltd., Sheffield, to become secretary of Herbert Alexander and Co., Ltd., Leeds.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., has acquired new premises at 36, Broad Street, Peterhead (telephone, Peterhead 376), in order to deal with the growing radio service requirements of the Peterhead fishing fleet.

REGENT OIL COMPANY, Ltd., 117, Park Street, London, W.1, states that Mr. G. E. Gordon Hope-Johnstone, general sales manager, has been appointed sales director. Mr. J. A. J. Nicholas, at present Midlands branch manager, is to become general sales manager.

ARMSTRONG SIDDELEY MOTORS, Ltd., Coventry, announces that it has made an arrangement with Diesel Equipment, Ltd., Uxbridge, whereby the latter company will manufacture a range of generating and lighting equipments incorporating the Armstrong Siddeley diesel engine.

THE TEES SIDE BRIDGE AND ENGINEERING WORKS, Ltd., Middlesbrough, announces that Mr. J. Barclay Peat, M.I.C.E., has retired from the office of managing director and has been appointed deputy chairman of the company. Mr. Wilfred L. Fletcher, A.M.I.C.E., A.M.I.Struct.E., has been appointed managing director.

THE MINISTRY OF TRANSPORT states that Mr. John Ryan has been appointed a part-time member of the British Transport Commission; Mr. G. F. Sinclair has been appointed a whole-time member of the Road Haulage Executive, and Sir Herbert Merrett and Mr. G. Nicholson have become part-time members of the Railway Executive.

THE BRITISH BROADCASTING CORPORATION announces the following appointments in its engineering division: Mr. F. C. McLean, M.I.E.E., head of the newly-formed engineering projects group; Mr. E. L. E. Pawley, M.I.E.E., head of the engineering services group, and Mr. A. N. Thomas, A.M.I.E.E., head of the planning and installation department.

Contracts

BRAITHWAITE AND CO., ENGINEERS, LTD., has obtained a contract valued at £2,400,000 for the development of the Port of Chittagong. A series of screw pile jetties is to be constructed comprising seven berths for ships of up to 10,000 tons each. The consulting engineers for the project are Messrs. Rendel, Palmer and Tritton; Merz and McLellan; and Vattenbyggnadsbyran (Stockholm).

Catalogues

B.E.N. PATENTS, Ltd., High Wycombe, Bucks.—Leaflets No. CB. 95, B.E.N. pulsator pre-set air meter, and C.B. 93, air power for garages and service stations.

CHANCE BROTHERS, Ltd., 28, St. James's Square, London, S.W.1.—Illustrated catalogue featuring the "Sumo" new submersible and portable electrical pumping unit.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, 17.—Illustrated booklet No. 7703/1 on heating elements for industrial applications.

Notes and Memoranda

Rail and Road

INSTITUTE OF THE MOTOR INDUSTRY.—The Council of the Institute of the Motor Industry has decided to hold the fifth annual summer school at St. Catharine's College, Cambridge, from August 25–September 1, 1951. As in former years, the school will be open to both members and non-members of the Institute and enrolments can now be accepted by the Secretary, Institute of the Motor Industry, 40, Queen's Gate, London, S.W.7.

CONDUCTOR RAIL DE-ICING EQUIPMENT.—In THE ENGINEER of November 21, 1947, we illustrated and described the conductor rail de-icing equipment which was being installed on the open sections of rail tracks of the London Transport system. There are now some 811 of these equipments in use on the system and when icy conditions are forecast the de-icing baths are brought into use during the early evening, to ensure an even distribution of anti-freeze solution before traffic ceases for the night. Providing the machines are switched into service at least two hours before cessation of traffic, the amount of solution spread is sufficient to prevent the icing-up of the conductor rail before traffic recommences some six hours later. In normal weather the machines are switched off after commencement of traffic the following morning, but in very severe conditions they may be kept in use continuously. Up till recently machines have been switched on or off by hand. An experimental thermostatically-controlled equipment was recently installed on the District Line at Barons Court, adjacent to a meteorological research apparatus and its bath is automatically switched into service when the temperature drops to 36 deg. Fah.

Air and Water

LLOYD'S REGISTER WRECK RETURNS.—Lloyds' Register of Shipping statistical summary of vessels of 100 tons and upwards totally lost or broken up during the quarter ended March 31, 1950, shows that fifty-four ships, totalling 59,188 tons gross, were lost due to casualty, including fifty-three steamers and motorships amounting to 59,044 tons gross, of which ten ships, of 16,917 tons gross, belonged to Great Britain and Northern Ireland. Ships broken up, through causes other than casualty, totalled 211,665 tons gross, representing sixty-eight ships, all being steamers and motorships, and of these, twenty-four ships, totalling 116,498 tons gross, were owned in Great Britain and Northern Ireland. The gross reduction in the world mercantile marine from all causes was 122 ships, representing 270,853 tons gross.

Miscellanea

IRON AND STEEL PRICES.—The Minister of Supply has made a new Order amending maximum prices for a limited range of iron and steel products, the principal of which is terneplate. It is entitled the "Iron and Steel Prices (No. 5) Order, 1950," and came into operation on December 14th.

THORNHILL POWER STATION EXTENSION.—The British Electricity Authority says that consent for the extension of the Thornhill power station, near Dewsbury, Yorks, has been received from the Minister of Fuel and Power. The authorisation covers the installation of one 45,000kW turbo-alternator set and one boiler with an evaporative capacity of 180,000 lb per hour, and the construction of a cooling tower.

NICKEL PRICE INCREASE.—The International Nickel Company of Canada, Ltd., and its associated companies, the International Nickel Company, Inc., of the U.S.A., and the Mond Nickel Company, Ltd., in the United Kingdom, have announced that their prices for refined nickel are being increased immediately. The Mond Nickel Company, Ltd., is raising its price in the United Kingdom to £406 per ton delivered works, with appropriate increases for other countries.

POST OFFICE, 1950.—A review of the activities of the Post Office during 1950, with some reference to trends that have influenced developments since the war, is given in a book entitled "Post Office, 1950," published by H.M. Stationery Office (price 2s. 6d.). In a foreword, the Postmaster-General explains that the purpose of the book is to present the public with a popular account of the work of the Post Office. Engineering research and development, inland and overseas telecommunications, inland and overseas postal services, and supplies and maintenance are among the topics dealt with in the book.

BRITISH RUSTING STANDARDS.—In December, 1949, the British Iron and Steel Research Association issued a series of photographs at natural size depicting different grades of breakdown by rusting of painted steel surfaces. Reprints of these photographs were made freely available in the hope that comparisons in this important field would become more uniform. It has now been announced that the standards have been accepted for use by the American Waterworks Association in their exposure tests.

COKE-OVEN PLANT IN SOUTH AFRICA.—A battery of fifty-four coke ovens forming part of the new Vanderbijl Park Steelworks in South Africa has now been put into operation. This complete coke-making installation, which will carbonise over 1100 tons of coal per day and has cost some £1,500,000, includes coal and coke-handling equipment and comprehensive by-products recovery and treatment plants. It has been built for the South African Iron and Steel Industrial Corporation, Ltd., by the Woodall-Duckham Company of London, and is the fifth coke-oven installation to be built for the Corporation by that company.

THE HEAVISIDE CENTENARY VOLUME.—To commemorate the centenary of Oliver Heaviside, the Institution of Electrical Engineers, Savoy Place, London, W.C.2, has published "The Heaviside Centenary Volume." This volume of ninety-eight pages contains a full account of the proceedings at the Heaviside Centenary Meeting which was held at the Institution on May 18, 1950; it includes the lectures and papers that were presented on that occasion as an appreciation of the different aspects of Heaviside and his work. Copies of the volume can be obtained from the Institution at the address given above, the cost being 10s., post free, to non-members.

I.E.E. MEMBERSHIP DESIGNATION.—Three years ago the council of the Institution of Electrical Engineers stated that it was keeping careful watch to prevent the misuse of the initials designating membership and that, should the need arise, action would be taken in the High Court against offenders. Since 1947 the council has taken action in thirty-three cases of the kind and has brought matters to a satisfactory conclusion without recourse to the Courts. In one recent case, however, Court action has been necessary, the result being a High Court Order restraining the defendant from using the initials M.I.E.E. and awarding the Institution the costs of the action.

PATENTS AND REGISTERED DESIGNS FOR ISRAEL.—The Board of Trade says that an agreement has been concluded between the British and Israel Governments whereby the time for making belated applications for United Kingdom patents or for registration of industrial designs, with priority based on a corresponding application in Israel on or after May 15, 1947, may be extended until a date not later than January 31, 1951. A corresponding extension will be granted by the Government of Israel for making applications in that country founded upon applications in the United Kingdom. The rules giving statutory effect to this announcement can be obtained from H.M. Stationery Office.

INCORPORATED BENEVOLENT FUND OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—Each year it is customary for the President of the Institution of Electrical Engineers to make an appeal to the Institution's members for support of the Benevolent Fund and Homes Fund. This year Sir Archibald Gill, in his appeal, states that the residential estate, which is the physical expression of the Homes Fund, is well launched. The first eight houses, which will provide homes for some of those in distress, are completed and it is hoped to start on the construction of another eight houses in 1951. Of the total of £50,000 required for the complete scheme, a sum of £16,000 (less than 10s. per member) is still needed.

RADIO TELEPHONE SYSTEMS IN EAST AFRICA.—The Marconi beam radio link, which has been in operation between Nairobi and Nakuru for more than a year, has proved so successful that the East African Posts and Telegraphs Department proposes to install a number of other v.h.f. links. It is planned to establish radio links between the telephone systems of Kampala and Jinja, Jinja and Nakuru, and Tanga and Dar-es-Salaam. Similarly, by 1952 Nairobi should be linked with Mombasa, Mombasa with Tanga and Dar-es-Salaam with Dodoma. A radio survey is at present being carried out in the coastal areas of East Africa, using radio equipment mounted in motor vehicles, as a result of which it is expected that improved knowledge of v.h.f. propagation in tropical areas will be gained.

British Patent Specifications

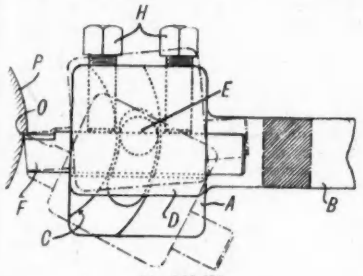
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

TOOLS AND WORKSHOP APPLIANCES

644,991. November 5, 1946.—IMPROVEMENTS IN OR RELATING TO TOOL-HOLDERS FOR TURRET LATHES AND LIKE MACHINE TOOLS, Victor Jean Desverchere, of 176, Avenue Lacassagne, Lyon, France.

The tool-holder described is designed to limit the number of tools required for general use, without having to grind the upper face of a tool when it is desired to alter one of the characteristic angles. In the drawing a side view of a tool-holder is shown. The tool-holder comprises a support *A* carried by a shank *B*. The machined vertical face of support has in it a curved groove *C* with its centre at a point *O*



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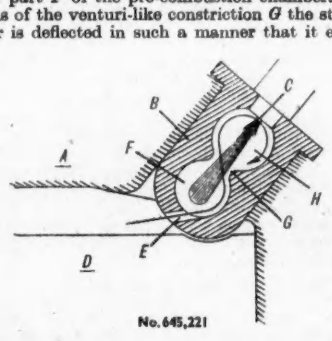
in front of support and approximately on a level with the axis of the lathe. A tool-carrier *D* arranged to slide against the machined vertical face of support has a projection which engages groove *C*. The carrier may be locked at any desired position by means of a gudgeon *E* in an opening in the support. The whole of one face of the tool-carrier slides against the vertical face of the support. The tool-carrier has a bore substantially parallel to the face of support and receives the cylindrical shank of the tool *F*, which is locked by screws *H*. The tool is so adjusted that its point is at the point *O*, as indicated. The tool can be rotated about two axes passing through the point *O*, one horizontal and parallel to the axis of the work *P* to be turned (by displacing the tool-carrier *D* along its groove *C* on the support), and the other one, also approximately horizontal by rotating the tool *G* itself within its bore.—*October* 25, 1950.

INTERNAL COMBUSTION ENGINES

645,221. March 15, 1948.—IMPROVEMENTS IN OR RELATING TO PRE-COMBUSTION CHAMBERS FOR INTERNAL COMBUSTION ENGINES, Steyr-Daimler-Puch Aktiengesellschaft, 4, Schönauerstrasse. Steyer, Austria.

Referring to the drawing, into the cylinder head *A* is inserted the cross-flow pre-combustion chamber *B*, which at its upper end supports the fuel injection nozzle *C*. The injection nozzle lies in the longitudinal axis of the pre-combustion chamber or parallel to the axis. During the upward stroke of the piston *D* a portion of the compressed combustion air flows through one or more connecting passages *E* tangentially into the lower part *F* of the pre-combustion chamber. By means of the venturi-like constriction *G* the stream of air is deflected in such a manner that it enters



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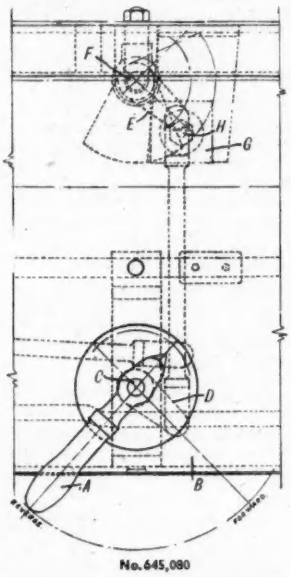
the upper part of the pre-combustion chamber at the opposite side. The stream of air follows the curvature of the wall of the upper half of the pre-combustion chamber and sweeps past the nozzle transversely to the direction of injection. The fuel jet thus strikes through the entering hot stream of air in the upper part *H* of the pre-combustion chamber and in the constriction *G* of the chamber. An intimate intermixture of the fuel with the combustion air in the lower part *F* of the chamber is thus obtained. It is also possible, through the flow of air being guided transversely to the direction of the fuel jet, to convey the injected fuel as far as possible in an unbroken form to the lower part *F* of the pre-combustion chamber and to the connecting passages *E*.—*October* 25, 1950.

645,080. January 27, 1949.—IMPROVEMENTS IN OR RELATING TO CONTROLLING DIESEL LOCOMOTIVES, Andrew Barclay, Sons and Co., Ltd., and Harold Kewney, both of Caledonia Works, Kilmarnock, Ayrshire.

The device described provides a means of preventing attempted reversal of a locomotive before it comes to a stop. In the drawing, part of the control desk assembly of a diesel locomotive is shown, and *A* denotes a forward and reverse



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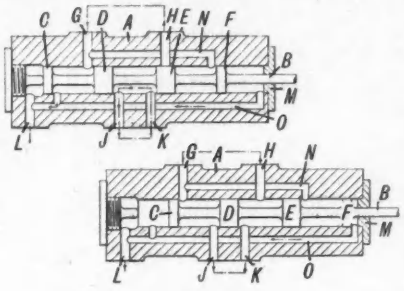
control handle mounted on the desk *B*. The handle is secured on the upper end of a spindle *C* on which also is secured an arm *D* connected through the medium of a link with an arm *E* on the upper end of a spindle *F*. The lower end of the spindle is connected to the spindle of the forward and reverse control valve of the locomotive. Interposed in an oil circuit which is connected with the transmission is an automatic valve *G* which is held open by the pressure of the oil in circulation and has a pin *H* which protrudes while the valve is open. When protruding the pin intersects the path of a sectoral lever arm *H* secured on the lower end portion of the spindle *F*. Only when the oil pressure in the oil circuit falls does the pin clear the path of the arm *H* so as to permit movement of the handle to effect reversal of the locomotive. After reversal has been effected and while the locomotive is running, the pin again protrudes into the path of the arm, and the handle cannot be shifted to forward running position until the locomotive has been stopped.—*October* 25, 1950.

GAS TURBINES

644,212. March 12, 1948.—IMPROVEMENTS IN OR RELATING TO GAS TURBINE FUEL SYSTEMS, C. A. Parsons and Co., Ltd., of Heaton Works, Newcastle-upon-Tyne, 6, Northumberland, and Frank Medcalfe, of the company's address.

This invention relates to gas turbine fuel systems and more specifically to emergency cut-off valves for fuel supply to a combustion chamber burner. Its purpose is to provide improved or simplified emergency cut-off valves. Referring to the accompanying drawings, the lower view is a longitudinal cross-sectional view of the fuel cut-off device shown in the operative position; in the upper view it is shown in the "shut-off" position. As applied to the fuel supply line to a gas turbine combustion chamber, has adjacent to its burner a body *A* with a longitudinal bore accommodating a plunger *B* with four piston-like parts *C*, *D*, *E*, and *F*. At about the centre of the body there are two radial ducts *G*, *H* communicating with the cylindrical bore; two further ducts *J*, *K* in the body are set out of register with the ducts *G*, *H*, and a single duct *L* at the inner end of the body is provided for connection to a fuel drain. The two ducts *J*, *K* are connected respectively to a liquid fuel pump inlet and outlet. The duct *H* is connected to the burner and *G* is connected to the discharge point of the burner to convey "spilled" oil by-passing the burner. At the outer end of the bore a suitable gland *M* is provided. The



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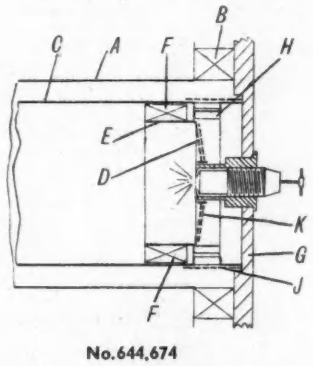
plunger may be operated by hand by servo-piston or any other convenient means. In the normal position (see the lower view), with the plant on load, oil is pumped under pressure into the duct *K*, whence it passes out through the duct *H* to the burner; the plunger in this position occupies its outermost position in relation to the valve body. Under these conditions spilled oil from the burner enters the duct *G* and leaves by the duct *J* to return to the fuel supply system at a point adjacent to the pump inlet. When it is required to cut off the oil fuel supply from the combustion chamber, the valve is moved to the innermost end of its stroke, as shown in the upper view. Oil then entering through the duct *K* returns to the pump inlet by way of the duct *J*, the duct *H* is closed by the piston *E* and "spilled" oil returns by way of the duct *G*, whence it passes to the drain through the duct *L*. Thus, although the fuel pump will continue to operate, the oil will by-pass the burner and the "spill" pressure is relieved owing to connection with the drain duct. If desired means may be provided for maintaining the plunger substantially in balance, by pressure-equalising passages *N* and *O* in the valve body.—*October* 4, 1950.

644,674. May 11, 1948.—IMPROVEMENTS IN OR RELATING TO COMBUSTION CHAMBERS, Robert Francis Darling, of 6, The Dene, Monkseaton, and The Parsons and Marine Engineering Turbine Research and Development Association, of Pametrada Research Station, Wallsend.

This invention concerns combustion chambers for the continuous combustion of fuel in an air stream and is applicable particularly, though not exclusively, to combustion chambers for gas turbines. As applied to a combustion chamber for a gas turbine, a cylindrical outer air casing *A* is fitted at one end with radial straightening vanes *B* for



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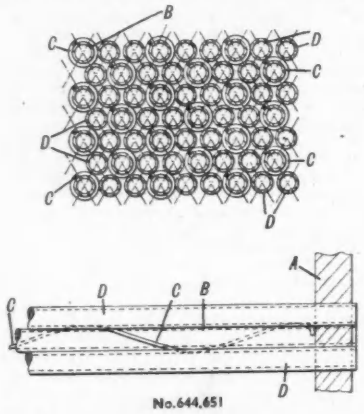
directing the air uniformly around the periphery of the combustion chamber. Centrally disposed within the air casing is a vessel *C* of heat-resisting material constituting a flame tube, this tube being closed at its upstream end by a shallow conical back plate *D* pierced by a number of axial holes through which some of the combustion air enters. The back plate is attached to a short cylinder *E* of a diameter slightly less than that of the flame tube; the annular space between this cylinder and the flame tube is occupied by a set of swirl vanes *F* attached to the cylinder. Projecting through a hole in the centre of the back plate is an injector for admitting liquid fuel in the form of a highly atomised conical spray. The flame tube *C* is continued past the swirl vanes so as to touch a foundation plate *G* at the upstream end of the combustion chamber and near this point the flame tube has a number of slots *H* which may be covered or uncovered by a lantern ring *J* encircling this portion

of the flame tube. The lantern ring has slots similar to those in the flame tube so that by rotating the ring the amount of air admitted through the slots may be controlled. In a modified construction the back plate damper *K* is omitted and a conical baffle near the back plate causes the whole of the combustion air to flow over the plate, thereby increasing the rate of heat transmission from the outside of the back plate to the surrounding air.—*October* 18, 1950.

HEAT EXCHANGERS

644,651. March 19, 1948.—IMPROVEMENTS IN OR RELATING TO TUBULAR HEAT EXCHANGERS, C. A. Parsons and Co., Ltd., of Heaton Works, Newcastle-upon-Tyne, 6, and Charles Hopper, of the same address.

This invention is designed to provide improved methods of constructing tubular heat exchangers. The drawings show a cross-sectional view of part of a heat exchanger and an enlarged longitudinal sectional view of one part. As applied to a tubular heat exchanger for use in a gas turbine cycle, a plurality of horizontal rows of tubes, each tube being of $\frac{3}{4}$in outside diameter, is provided. The tubes are grouped on a $\frac{7}{8}$in triangular pitch and are expanded at both ends into tube plates *A*, the hot gases pass through the tubes axially and air passes over the external surface in the reverse direction; with this disposition of the tubes a space of $\frac{1}{4}$in exists between each tube. Every third tube *B* in every row of tubes is encompassed by a wire helix *C*, the pitch of which is $2\frac{1}{8}$in, i.e., three times the pitch



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of the tubes. The tubes *B* are uniformly distributed throughout the whole group. Each wire helix, other than those at the outer rows of tubes, gives support to six tubes, so that the complete nest is supported in all transverse directions. In order to insert the wire helices *C* after all the tubes *D* have been fitted to the tube plates, the helices are threaded through the remaining holes in the tube plates. Finally, the remaining tubes *B* are inserted with a slight turning motion to enter and pass through the respective helices. If desired, a tapered plug may be fitted to the forward end of each tube *B* to aid the insertion of those tubes into their respective helices. The tubes *B* and *D* are then ready for final welding to the tube plates *A*. Replacement of tubes *B* offers no difficulties since a tube end may readily be upset after cutting away the weld metal and the tube withdrawn without disturbing the lay of the wire helix surrounding it. A wire helix may also be withdrawn readily for inspection before a new tube is inserted.—*October* 18, 1950.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Thurs., Dec. 28th.—LUTON BRANCH: George Hotel, Luton, "Motor Control Gear," R. F. Mathieson, 8 p.m.

British Institution of Radio Engineers

Thurs., Jan. 4th.—N.W. SECTION: College of Technology, Manchester, "Marine Radar," G. W. L. Davis, 6.45 p.m.

Electric Railway Society

Sat., Jan. 6th.—Fred Tallant Hall, Drummond Street, London, N.W.1, "A Glance at American Electrics," H. W. A. Linecar, 3 p.m.

Illuminating Engineering Society

Wed., Jan. 3rd.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle-on-Tyne, "Design of School Lighting," J. F. Roper, 6.15 p.m.——SWANSEA GROUP: 4, Northampton Gardens, Swansea, "Lighting of Departmental Stores," A. W. Jervis, 5.45 p.m.

Thurs., Jan. 4th.—CARDIFF CENTRE: S. Wales Electricity Board Demonstration Theatre, The Hayes, Cardiff, "Lighting of Departmental Stores," A. W. Jervis, 5.45 p.m.——EXETER GROUP: Agricultural House, Queen Street, Exeter, "Floodlighting," R. S. Hazell, 7 p.m.

Incorporated Plant Engineers

Fri., Dec. 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Nylon Hosiery Manufacture," Bert Hall, 7.30 p.m.

Tues., Jan. 2nd.—S. WALES BRANCH: Grand Hotel, Westgate Street, Cardiff, Members' Plant Problems, 7.30 p.m.

Thurs., Jan. 4th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, Film, "Pulverised Fuel," D. J. U. Murray, 7.30 p.m.

Institute of Industrial Supervisors

Tues., Jan. 2nd.—KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, Annual General Meeting and Section President's Address, 7.30 p.m.

Thurs., Jan. 4th.—COVENTRY SECTION: Geisha Cafe, Hertford Street, Coventry, Annual General Meeting and Members' Discussion Night, 7.30 p.m.——CARDIFF SECTION: Technical College, Clarence Street, Newport, "Joint Consultation—with Particular Reference to Supervisors," J. L. Hamilton, 7 p.m.——WARRINGTON SECTION: White Hart Hotel, Warrington, "The Foreman and Costing," S. C. Roberts, 7 p.m.

Institution of Civil Engineers

Tues., Jan. 2nd.—Great George Street, Westminster, S.W.1, "Buildings for Air Transport Operators," R. G. Edkins, 5.30 p.m.

Institution of Electrical Engineers

Fri, Jan. 5th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Mechanical Handling," Joint Meeting with the Institution of Mechanical Engineers, 5.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Jan. 9th.—39, Elmbank Crescent, Glasgow, "The Mechanical Engineering Research Laboratory, East Kilbride, Scotland," G. A. Hankins, 6.30 p.m.

Institution of Heating and Ventilating Engineers

Wed., Jan. 3rd.—E. MIDLANDS BRANCH: Gas Show Rooms, Nottingham, "District Heating in France," E. A. Pearce, 6.30 p.m.

Institution of Mechanical Engineers

Tues., Jan. 2nd.—COVENTRY A.D. CENTRE: Craven Arms Hotel, High Street, Coventry, "Some Factors Governing the Performance of Crankcase Lubricating Oils," A. Towle, 7 p.m.

Fri., Jan. 5th.—Storey's Gate, St. James's Park, S.W.1, "Mechanical Handling," Joint Meeting with the Institution of Electrical Engineers, 5.30 p.m.

Institution of Structural Engineers

Fri., Jan. 5th.—WESTERN COUNTIES BRANCH: Grand Hotel, Bristol, "The Reconstruction of the Colston Hall, Bristol," N. G. T. Ball, 6.15 p.m.

Junior Institution of Engineers

Fri., Dec. 29th.—39, Victoria Street, London, S.W.1, Film Evening, "Distinguished Company," "Wonder Jet," "Once Upon a Time," 6.30 p.m.

Wed., Jan. 3rd.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Design in the Home," 7 p.m.

Fri., Jan. 5th.—WESTERN GROUP OF MEMBERS: College of Technology, Unity Street, Bristol, 1, "Materials in relation to Gas Turbine Design," K. L. Buckle, 7.30 p.m.——39, Victoria Street, S.W.1, Film Evening, "Prelude to Power," introduced by H. L. Greer, 6.30 p.m.

Manchester Association of Engineers

Fri., Jan. 5th.—Engineers' Club, Albert Square, Manchester, "Automatic Welding," E. Hindson, 6.45 p.m.

Launches and Trial Trips

PATRICIA, passenger and cargo liner; built by Swan, Hunter and Wigham Richardson, Ltd., for Rederiaktiebolaget Svenska Lloyd, Sweden; length between perpendiculars 415ft 6in, breadth moulded 58ft, depth moulded 31ft 9in, 2300 tons deadweight; one set of single reduction geared turbines, taking high-pressure superheated steam from two Babcock and Wilcox boilers. Launch, November 8th.

ATHELSULTAN, motor tanker; built by Smith's Dock Company, Ltd., for the Athel Line, Ltd.; length between perpendiculars 465ft, breadth moulded 63ft 3$\frac{1}{2}$in, depth moulded 34ft 7in, 12,500 tons deadweight, Hawthorn-Doxford oil engine, four cylinders, 4450 b.h.p. at 112 r.p.m. Launch, November 9th.

VERENA, turbine tanker; built by Harland and Wolff, Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length between perpendiculars 610ft, breadth moulded 80ft 6in., depth moulded 45ft, deadweight 28,000 tons; single set of double reduction geared turbines taking high-pressure superheated steam from three Foster-Wheeler boilers, 11,000 service s.h.p., two 400kW turbo-generators. Trial, November 10th.

AFRIC, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Prince Line Ltd.; length between perpendiculars 349ft., breadth 51ft 3in, depth moulded 30ft 9in, deadweight 4600 tons; Hawthorn-Doxford opposed piston oil engine, arranged to burn heavy fuel, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. Trial November 21st.

ASCANIUS, cargo and passenger liner; built by Harland and Wolff, Ltd., for Alfred Holt and Co.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded 35ft; Harland-Burmeister and Wain two-cycle opposed piston oil engine, seven cylinders, main cylinders 750mm diameter by 1500mm stroke, exhaust cylinders 752mm diameter by 500mm stroke. Trial, November 21st.

BRITISH ROVER, motor tanker; built by Joseph L. Thompson and Sons, Ltd., for the British Tanker Company, Ltd.; length overall 423ft, breadth 56ft, depth 30ft 1in, deadweight 8400 tons; Doxford oil engine, three cylinders, 600mm diameter by 2320mm combined stroke. Launch, November 24th.

LONDON ENTERPRISE, motor tanker; built by the Furness Shipbuilding Company, Ltd., for the London and Overseas Freighters, Ltd.; length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, deadweight 16,325 tons on 29ft 1$\frac{1}{4}$in draught; North-Eastern Marine-Doxford two-stroke opposed piston engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 114 r.p.m., two Scotch boilers. Trial, November 26th.

WATERLAND, motor collier; built by the Burntisland Shipbuilding Company, Ltd., for the Shipping and Coal Company, Ltd.; length between perpendiculars 302ft, breadth 44ft 6in, depth moulded 21ft. 10in, deadweight 4050 tons; Kincaid-Harland-Burmeister and Wain single-acting, two-cycle, trunk piston engine, five cylinders, 500mm diameter by 900mm stroke, 1500 b.h.p. Trial, November 27th.

KENYA, passenger liner; built by Barclay Curle and Co., Ltd., for the British India Steam Navigation Company, Ltd.; length overall 540ft, breadth 71ft, depth 38ft 6in, 15,000 gross tonnage; two sets of single-reduction geared turbines take high-pressure and high-temperature steam from three boilers. Launch, November 28th.

LIMATULA, motor tanker; built by Smith's Dock Company, Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length between perpendiculars 425ft, breadth moulded 54ft 3in, depth moulded 31ft, deadweight 9445 tons; Hawthorn-Werkspoor pressure-charged, single-acting, four-stroke oil engine, six cylinders, 2700 b.h.p. at 120 r.p.m. Trial, November 30th.

BINTANG, cargo liner; built by the Netherlands Dock and Shipbuilding Company, for N.V. Stoomvaart Mij, "Nederland"; length between perpendiculars 435ft, breadth moulded 59ft, depth moulded 39ft 5$\frac{1}{2}$in, deadweight 8950 tons; N.D.S.M.-Stork double-acting, two-stroke diesel engine, six cylinders 720mm diameter by 1200mm stroke, 6400 b.h.p. at 124 r.p.m. Trial, November 30th.

SINGAPORE, cargo liner; built by John Brown and Co., Ltd., for the Peninsula and Oriental Steam Navigation Company; length 525ft, breadth 70ft, deadweight 10,750 tons; geared turbines, 13,000 s.h.p., service speed 18 knots. Launch, December 1st.

BRITISH SURVEYOR, motor tanker; built by Harland and Wolff, Ltd., for the British Tanker Company, Ltd.; length between perpendiculars 463ft, breadth moulded 61ft 6in, depth moulded 34ft, deadweight 12,300 tons; Harland-Burmeister and Wain single-acting, four-stroke diesel engine, six cylinders, 740mm diameter by 1500mm stroke, two single-ended, multi-tubular boilers. Trial, December 8th.

MAGWA, motor tanker; built by the Furness Shipbuilding Company, Ltd., for the Afran Transport Company of Liberia; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,625 tons; Hawthorn-Doxford single-acting, two-stroke oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m. Launch, December 8th.

PORT ADELAIDE, refrigerated cargo ship; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the Port Line, Ltd.; length between perpendiculars 460ft, breadth moulded 64ft 6in, depth moulded 41ft 6$\frac{1}{2}$in, deadweight 10,700 tons; Hawthorn-Doxford oil engine, six cylinders, 725mm diameter by 2250mm combined stroke, 7500 b.h.p. at 112 r.p.m. Launch, December 8th.

NEW MODEL DIESEL ENGINES.—J. and H. McLaren, Ltd., announces that from January 1st its vertical engines will be available with direct-injection and be designated type "M." The new models have improved thermal efficiency, 10 per cent less fuel consumption, and a new cylinder head having two inlet and two exhaust valves with a four-hole injector centrally disposed.